SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1899.

GENERAL PHYSICS.

1460. *Elasticity of a Pendulum.* **E. Almansi.** (N. Cimento, 9. pp. 260–278, 1899.)—The author deals mathematically with the influence of elastic deformations upon the motion of a reversible pendulum. To simplify matters, he assumes the hollow cylindrical portion between the knife edges to be the only part subject to elastic deformation, and calculates the bending moment for any cross-section and for any angle of deflection.

E. E. F.

1461. *Pumps.* **F. Neesen.** (Verh. Deutsch. Phys. Gesell. 1. pp. 90–94, 1899.)—Description of improvements in mercury air-pumps, and comparative investigations into the speeds of working of different kinds of air-pumps. A. D.

1462. *Flow Structures.* **K. Mack.** (Wied. Annalen, 68. 2. pp. 183–195, 1899.)—The author studied the vortex structures produced by allowing a solution of fuchsin to flow into water from below, the head and time of flow being accurately known. He studied particularly the effects of gravitation upon the shape assumed by the flow structures. For this purpose he varied the density of the solution by altering its concentration. The usual type of structure was the well-known upright mushroom, consisting of a stem of length varying with the pressure, and an upper flat part edged by a vortex ring. On stopping the flow the mushroom would become broader and flatter, eventually forming a pretty uniform horizontal layer of coloured liquid. When, however, the solution was dense, the vortex ring would drop down, and the liquid that followed would produce a kind of horn projecting above its surface. The author also studied the manner in which a new mushroom would deform an already existing horizontal layer. He found that it would lift it up as if it were a heavy cloth, and the liquid would run down the sides of the mushroom as if the latter were solid. It would then get caught in the vortex and take part in its rotation. Non-circular apertures always produced circular mushrooms. E. E. F.

1463. *Absolute Measurement of Time.* **G. Lippmann.** (Comptes Rendus, 128. pp. 1137–1142, 1899.)—From the two expressions for an attactive force, $F=k^2\frac{Mm}{r^2}$ (M and m being masses, separated by the distance r), and $F=m\frac{d^2x}{dt^2}$, the author derives an equation for the Newtonian constant, $k^2=r^2\frac{d^2x}{dt^2}\Big/M$. As r and x are lengths, the dimensions of k are l^0t^{-1}. We know that $k=\frac{1}{3862}$. This value does not change when we pass from the centimetre and gramme to the metre and ton. There is only one time interval, the second, for which $k=\frac{1}{3862}$, and only one unit, θ, for which k becomes 1. If we adopt that unit, k disappears from the expressions for F, which become $F=\frac{Mm}{r^2}$, $F=m\frac{d^2x}{d\theta^2}$. The relation between k, t, θ, is $kt=\theta$, that is, k is the numerical value of the old unit as function of the new unit, for which the Newtonian constant has unit value. In analogy to natural and common logarithms, the author speaks of natural time. To pass from natural time to any arbitrary common time, we must introduce a coefficient k which is the measure, in absolute value, of the arbitrary unit of time to be adopted. The author exemplifies such calculations. The duration in absolute measure of a pendulum oscillation follows from $\Theta=2\pi\sqrt{\frac{l}{\gamma}}$, where γ denotes the mass M of the earth divided by the square of the radius a; hence $\Theta=2\pi\sqrt{\frac{1}{\frac{4}{3}\pi\cdot5\cdot5}\cdot\frac{l}{a}}$. The length of the pendulum l which would make 3,600 oscillations in a natural hour can be deduced from $\frac{1}{3600}=2\pi\sqrt{\frac{1}{\frac{4}{3}\pi5\cdot5}\frac{l}{a}}$, whence $l=1{\cdot}02960m$ for Paris. These examples suggest a new method of determining k, which we know as the square root of the Newtonian constant. We calculate the duration of a movement, due to attraction, suppressing k in this calculation; we observe the movement in seconds, and divide the former value by the latter. The quotient will be k. Dividing, for instance, the value for Θ for a second pendulum by 2 (period of two seconds), we obtain $\frac{1}{3882}$. From observations of the moon, we find $k=\frac{1}{3864}$. In this way the exactness of formulæ can be checked. As regards the geodesial pendulum and the mass of the earth, compare Abstract No. 4, 1899. H. B.

1464. *Physical Constitution of the Moon.* **Lœwy** and **Puiseux.** (Comptes Rendus, 129. pp. 5–8, July 3, 1899.)—The authors, in presenting to the Academy of Sciences the *fourth* part of the large photographic Atlas of the Moon, which they are compiling from photographs taken at the Paris Observatory, offer suggestions as to the information these photographs give concerning the state of the lunar surface. C. P. B.

1465. *Equations in Planetary Theory.* **H. Ludendorff.** (Göttingen Nachrichten, 4. pp. 345–348, 1898.)—This is a purely mathematical paper, dealing with certain equations of condition in the theory of the minor planets as affected by the perturbations caused by Jupiter, and is really a continuation of a more elaborate paper given by the author in 1897. C. P. B.

1466. *Influence of Moon on Seismic Movements.* **U. Landi.** (Revista Scientifica, 30. pp. 237–239, 1898.)—The author debates whether there is any relation between the astronomical position of the moon and seismic movements. He states that "many earthquakes occur at '*equiluna*' and at '*lunistizio*,' that is when the moon is in the plane of the equator or when at the greatest distance from it, or when the sun and the moon have the same declination." A. Gs.

1467. *Density of the Earth.* **F. Richarz** and **O. Krigar-Menzel.** (Zeitschr. Instrumentenk. 19. pp. 40–56, 1899, also Abhandl. der Berl. Akad. 1898.)—Description of the balance used for measuring gravitational attraction, alternately above and below a 100-ton mass of lead, in the recent Berlin Academy and Prussian Government experiments (see 1899, Abstract No. 232). The value obtained is 5·505 ± 0·009. A. D.

1468. *Earth Tremors and Mercury Reflectors.* **G. Bigourdan.** (Comptes Rendus, 128. pp. 1147–1149, 1899.)—The article commences by stating the importance of being able to measure an image reflected from a mercury surface (as giving the only absolute method of determining the astronomical vertical), and the many difficulties encountered in such observations by reason of the vibration of the earth's surface. It has been suggested that these might be eliminated by observing at a depth below the surface of the ground, and the author has made experiments to test the idea, working at various depths and with mercury baths having varying thicknesses of film.

He finds evidence of two distinct types of tremors, which may be distinguished both by the depth at which they die out and their different effect on the reflected image. He describes one type as "undulations," the other as "vibrations."

"Undulations" cause very slow and regular movements of the reflected image, their duration varying from 0·25 to 0·5 second, with a mean amplitude of 2 or 3 seconds of arc during the day, but some attain an amplitude as great as 10 or 12 seconds arc; their direction is not constant but may take successively all orientations.

"Vibrations" are much more rapid and irregular, it being impossible to measure their duration, amplitude, or direction, but it is evident that their amplitude is much less than that of the undulations.

As regards their effect on the image, the undulations cause the reflected image to move, but, being so slow, do not obliterate it, while the vibrations entirely destroy the definition and render identification impossible.

The author finds it difficult to ascribe any single cause to explain these phenomena. He has compared the behaviour of the mercury surface at different depths below the surface of the ground, during various hours of the day, in Paris, and in the country, quite remote from habitations or traffic. From the facts observed he thinks it probable that the undulations are caused by displacements of large weights, such as passages of trains, heavy waggons, &c., while the vibrations are caused by the integration of smaller disturbances, and that it may be possible to greatly improve the conditions of reflection observations if they are made at some distance below the surface of the ground. C. P. B.

1469. *Helmholtz's Theory of Sun's Heat.* **T. J. J. See.** (Science, 9. pp. 737–740, 1899.—Paper read before the Philosophical Society of Washington, May 13, 1899). The first portion of the paper consists of a summary of the conclusions deduced by Helmholtz for the amount of heat produced by the shrinkage of the sun's mass. The remainder gives in a discursive manner the present author's application of "Lane's Law" to estimate the probable duration of the sun's heat. His conclusion is that the future duration of the sun's heat can hardly exceed four million years, and consequently a corresponding limit is set for the continuation of animal and plant life upon our globe. C. P. B.

LIGHT.

1470. *Source of Monochromatic Light.* **C. Fabry** and **A. Perot.** (Comptes Rendus, 128. pp. 1156–1158, 1899.)—Sodium light has serious disadvantages, and the authors recommend the mercury arc light in vacuo, discovered by Arons; that is, the arc produced between mercury and mercury in a Torricellian vacuum in a ∩ tube or, in the pattern employed by the authors, in an outer closed tube and an axial open-ended tube. A shake of the apparatus completes the circuit by a splash of mercury and sets up the arc; and that the arc may be stable, a voltage of at least 30 volts is required. The principal radiations are: (1) violet, $\lambda = 0{\cdot}33580\mu$, cut out by yellow glass or a thin layer of bichromate of potash solution; (2) green, $\lambda = 0{\cdot}54607\mu$, cut out along with the preceding by a weak solution of eosine; (3) two yellows, $\lambda = 0{\cdot}57696$ and $0{\cdot}579066$, cut out by a few millimetres of a concentrated solution of chloride of didymium; and a mixture of this solution with bichromate of potash cuts out all except the green rays. The violet ray is very useful for photographic work; for this the yellow and green need not be eliminated, but it is necessary to interpose an acid solution of sulphate of quinine in order to get rid of some ultra-violet radiations. For lantern purposes the arc may be struck, in air, between mercury (+) and carbon (−); the lines are less fine than with mercury vacuum tubes, but they enable most optical experiments to be performed with mono-chromatic light. A. D.

1471. *Refractive Index of Pure Water.* **C. Bender.** (Wied. Annalen, 68. 2. pp. 343–349, 1899.)—The author determines the refractive index of pure water for the hydrogen lines $H\alpha$, $H\beta$, and $H\gamma$, by means of Pulfrich's refractometer, in which a cube takes the place of the prism. He finds that between 10° and 40° the refractive index of pure water is the same as that of water containing air. The alteration of the refractive index with the temperature is given by the following formulæ:—

$$H\alpha = 1{\cdot}3323004 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

$$H\beta = 1{\cdot}3382118 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

$$H\gamma = 1{\cdot}3414389 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

for temperatures between 10° and 40° C. E. E. F.

1472. *Telescopic Objective for Spectroscopic Use.* **C. S. Hastings.** (Amer. Journ. Sci. 7. pp. 267–270, 1899.)—Following on the lines of papers in the Amer. Journ. Sci. (see vol. xxxvii., 1889), the author announces that he has succeeded in making a four-glass objective with two free surfaces and an aperture of *f*/10. The focal plane is rigidly the same for all wave-lengths from A to K, and the colour correction is complete, even including chromatic difference of spherical aberration. The name suggested for this combination, whose action is the same upon light of all wave-lengths, is an isokumatic system. The optical work has been under the care of Mr. Brashear, of Allegheny. A. D.

1473. *Interference Fringes on Daguerreotypes.* **O. Wiener.** (Wied. Annalen, 68. 2. pp. 145–148, 1899.)—Interference plays a considerable part in the Daguerre process of photography. The interference is produced by the thin layer of silver iodide deposited on the silver plate. The author has demonstrated the existence of a periodic variation of the sensibility with the thickness of the deposit. He prepared a double wedge-shaped layer of the iodide by laying a silver plate on a wide glass tube and exposing both to the action of iodine vapour. The layer of iodised silver increased in thickness from the line of contact outwards. The plate thus prepared was exposed to the spectrum of an arc lamp produced by a slit normal to the line of contact. The developed plate then showed two or three fringes running parallel to the line of contact. On cutting another plate through in a direction normal to the line of contact, exposing and developing one half only, and observing the other through a blue glass, it was found that the interference fringes seen through the glass coincided with the fringes produced by the blue rays of the spectrum. This is in accordance with Daguerre's instruction to produce the layer having a yellow tinge, which absorbs the blue rays best. There is therefore a maximum whenever a ventral segment of the electric force coincides with the surface. E. E. F.

1474. *Daguerreotype as an Interference Process.* **H. Scholl.** (Wied. Annalen, 68. 2. pp. 149–182, 1899.)—The turbidity which plates of pure silver iodide acquire under the influence of light is not due to a chemical change but to a mechanical subdivision of the exposed layer, the final product being pure silver iodide, as before. This process requires the catalytic aid of oxidising substances such as oxygen, iodine, and the like. When Daguerre plates are exposed, the silver plate becomes iodised, and the silver iodide is reduced from the outer surface downwards. That the plates can be developed at all is due to the metallic silver at the surface.

The Daguerre plate possesses a maximum sensitiveness when the conditions for the reduction of the iodide are most favourable, *i.e.*, when the ventral segment of the stationary light waves lies in the surface of the iodide which is in contact with the air. This reacts upon the inner portions of the film. When a layer of iodide is enclosed between two transparent platinum mirrors, and is illuminated by violet light, it becomes the seat of an E.M.F., which shows that the iodine migrates to regions of least luminosity. A somewhat similar observation is made when the iodide is illuminated from the air side and from the silver side respectively, and the differences in behaviour are studied.

E. E. F.

1475. *Pressure Due to Radiation.* **W. Donle.** (Wied. Annalen, 68. 2. pp. 306–315, 1899.)—Various attempts have been made to determine the pressure to which the vanes of a radiometer are subjected owing to the radiation which impinges upon them. Schuster in one case found a pressure of 0·0294 dyne on a surface of 1 square cm., weighing 0·03 milligramme. The author has obtained some interesting results by means of a bifilar balance. For a Hefner candle he obtained 7×10^{-5} dynes per square cm., for a stearine candle 12×10^{-5}, for an Argand burner 75×10^{-5}, and for an Auer burner 45×10^{-5}. Various bifilar arrangements were used, but the best was that in which a bar of aluminium 1 mm. wide and 2 cm. long, was suspended by two cocoon fibres, and provided with a mica vane at one end and a glass counterpoise at the other. By a slight difference in the length of the two fibres it was ensured that the mirror attached to the bar always returned to the same zero. The results, especially at the higher vacua, are fairly in accordance with those of Crookes. An interesting question put was whether Röntgen rays produce any such pressure. In one experiment slight indications of pressure were obtained, but nothing definite could be concluded from them. E. E. F.

1476. *Absorption of Light in the Magnetic Field.* **A. Righi.** (N. Cimento, 9. pp. 295–302, 1899.)—The influence of an appreciable breadth in the absorption bands causes the colour of the light which appears on closing the circuit not to be complementary to that transmitted. Experiments with bromine and iodine previously unsuccessful have succeeded upon using thinner layers of the vapours. (See also 1899, Abstract No. 424.) A. D.

1477. *Correlation of Zeeman Effect.* **O. M. Corbino.** (Roma R. Accad. Lincei Atti, 8. pp. 250–254, 1899.)—Admitting that the curve of absorption for a circular ray is, with the exception of its displacement, the same as before, and that among the constants of a medium which determine the absorption by that medium are comprised all those which determine the index of refraction; it follows that the phenomena of anomalous magnetic rotatory polarisation with all their peculiarities can be deduced from the Zeeman phenomenon. So also can the symmetry of the phenomenon, with the aid of Helmholtz's anomalous-dispersion postulates; and so also can the double refraction by absorbent vapours, normal to the lines of force.

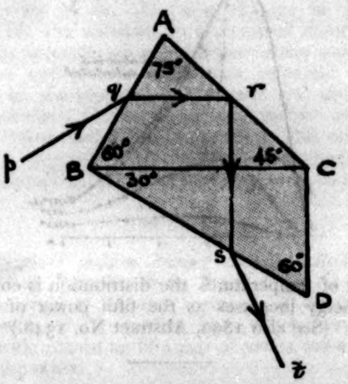
A. D.

1478. *Theory of the Zeeman Effect.* **W. Voigt.** (Wied. Annalen, 68. 2. pp. 352–364, 1899.)—Since the observed deviations from the "normal" type of Zeeman effect lie in the behaviour of the component, which, in the wave propagated normally to the lines of force, is again polarised normally to the lines of force, they are due to the anomalous behaviour of the component of the electric force which is parallel to the lines of force of the magnetic field. Following up this clue, the author works out modifications of the Hertzian equations which account for the quadruplets of Cornu and Becquerel, and allied forms.

E. E. F.

1479. *Magneto-Optic Phenomena.* **T. Preston.** (Nature, 60. pp. 175–180, June 22, 1899.)—This is a reprint of the author's Royal Institution lecture of May 12th. The portion on Complex Atoms deals with the natural grouping of the lines of certain metals in triplets, each triplet being supposed to be due to a different ion composing the atom. Not only do the lines of the various metals range themselves in similar groups, but the corresponding lines of the different spectra are *similarly* affected by the magnetic field. And further, not only is the character of the magnetic effect the same for the corresponding lines of the different metals of the same chemical group, but the actual magnitude of the resolution as measured by the quantity e/m is the same for the corresponding series of lines in the different spectra. This leads to the surmise that the ion which produces the lines A_1, A_2, A_3, &c., in the spectrum of zinc is the same as that which produces the corresponding series, A_1, A_2, A_3, &c., in cadmium, and the same for the corresponding sets in the other metals of this chemical group. In other words, not only is the atom a complex composed of an association of different ions, but the atoms of those substances which lie in the same chemical group are perhaps built up from the same kind of ions, or at least from ions which possess the same e/m, and the differences which exist in the materials thus constituted arises more from the manner of association of the ions in the atom than from differences in the fundamental character of the ions which build up the atoms; or it may be, indeed, that all ions are fundamentally the same, and that differences in the value of e/m, or in the character of the vibrations emitted by them, or in the spectral lines produced by them, may really arise from the manner in which they are associated together in building up the atom. E. E. F.

1480. *Spectroscope of Fixed Deviation.* **P. Pellin and A. Broca.** (Journ. de Physique, 8. pp. 314–319, June, 1899.)—The paper commences by considering the disadvantages of the usual plan of obtaining fixed deviation by introducing a reflecting surface into the prism train (first suggested by Fuchs, and later developed fully by Wadsworth), the chief of which are the possible lack of definition of the silvered mirror and its non-permanent nature. The authors then proceed to describe a plan for so designing a prism that the rays shall, after being refracted, undergo a total internal reflection before emergence, this being then equivalent to the previous system of prism and subsidiary mirror. The suggested form of prism, giving a constant deviation of 90°, is shown in the figure, the path of a ray at minimum deviation being also indicated.

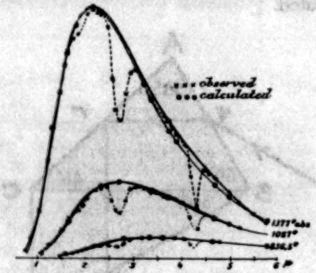


Successive wave-lengths from red to ultra-violet may be viewed in the centre of the field of the telescope by simply rotating the prism, the central ray being always at minimum deviation.

If greater dispersion than that given by one such prism is insufficient, several of similar construction may be used in series, and diagrams are given in the article showing the various dispositions of the apparatus which follow by using two or more prisms. C. P. B.

1481. *Magneto-Optic Phenomena.* **P. Drude.** (Verh. Deutsch. Phys. Gesell. 1. pp. 107–116, 1899.)—Systematic development of the equations. In metallic vapours, magnetised, the Hall effect is in every case of essential importance for the production of magneto-optic effects, while molecular currents are not so; the reverse being the case in the strongly magnetisable metals, iron, nickel, and cobalt. But the Hall effect, or the molecular currents, as the case may be, predominate over but do not exclude one another; both always contribute to some extent to the effect produced. A. D.

1482. *Energy in the Spectrum of a Black Body.* **O. Lummer** and **E. Pringsheim.** (Verh. Deutsch. Phys. Gesell. 1. pp. 23–41, 1899.)—The authors test the various formulæ for the distribution of the radiant energy of an "absolutely black" body, consisting of a uniformly heated hollow space provided with a small opening. The results for three different absolute temperatures, as compared with Paschen's formula, are given in the diagram. They show that within the unavoidable errors of the measurement of temperatures the distribution is correct, and the maximum energy increases as the fifth power of the absolute temperature. (See also 1899, Abstract No. 1348.) E. E. F.



1483. *Absorption Spectra of Gaseous Mixtures.* **P. Baccei.** (N. Cimento, 9. pp. 241–253, 1899.)—The author shows that the absorption due to a gas is the same whether it is alone or mixed with another gas, provided density and pressure remain the same. This means that the absorption due to a mixture of several gases is the sum of the absorptions due to the gases taken singly. E. E. F.

1484. *Spectrum Analysis.* **N. Lockyer.** (Nature, 59. pp.

535–539, 1899.)—The article is a review of the facts leading the author to adopt the theory of dissociation of matter with regard to temperature, in the course of which details are given of the laboratory experiments undertaken with the object of testing the hypothesis. C. P. B.

1485. *Currents Traversing Röntgenised Gases.* **W. Hillers.** (Wied. Annalen, 68. 2. pp. 196–232, 1899.)—The author has made a series of careful experiments concerning the manner in which the pressure of the gas between two plates affects the current which passes when they are brought to different potentials, and X-rays are allowed to traverse the gas. He finds, first of all, that the moisture of the gas does not affect either the potential or the current intensity. The course of the potential is embodied in the formula

$$V = \frac{bp}{c(p+c)}$$

where p is the pressure, b/c the potential at high pressures, and c the pressure at which the resistance reaches a maximum. The current intensity varies near c as the square root of the pressure. The conductivities of air, CO_2, and H_2, are in the ratio of 1 : 1·18 : 0·50, but the potential in the case of hydrogen is probably affected by an occlusion of hydrogen in the metallic places. The author has arrived at a pretty close valuation of the comparative case of dissociation of hydrogen and air, *i.e.*, at the comparative numbers of ions dissociated in unit volume under unit pressure when under the influence of the same Röntgen radiation. The ratio is 0·29 : 1, the dissociation of air being unity. For CO_2 the dissociation is very nearly the same as that of air.

E. E. F.

1486. *Mechanical Action during Röntgen Radiation.* **F. Neesen.** (Verh. Deutsch. Phys. Gesell. 1. pp. 69–73, 1899.)—Shows that the onset of Röntgen radiation is simultaneous with the development of a retarding force which brings to rest a rotating electrode consisting of a pair of vanes, metal on one side and mica on the other. A. D.

1487. *Absorption of Röntgen Rays by Air.* **J. Trowbridge** and **J. E. Burbank.** (Elect. Rev. N.Y. 34. p. 259, 1899.)—Difference between the rays transmitted through a column of air, 30 inches thick at 4 mm. pressure, and those transmitted through an equal column at atmospheric pressure could not be detected by the fluoroscope. A. D.

HEAT.

1488. *Thermal Expansion of Pure Nickel and Cobalt.* **A. E. Tutton.** (Roy. Soc. Proc. 65. pp. 161–162, June, 1899.)—The author has examined specimens of nickel and cobalt, specially purified by means of nickel carbonyl, with the interference dilatometer (Abstract 1017, 1898) between 6° and 121°. The coefficients of linear expansion α are:—

For nickel ......$\alpha = 0{\cdot}00001248 + 0{\cdot}0000000148\ t$
For cobalt ......$\alpha = 0{\cdot}00001208 + 0{\cdot}0000000128\ t$

T. E.

1489. *Boiling-Point of Hydrogen.* **J. Dewar.** (Proc. Chem. Soc. 15. pp. 70–71, 1899.)—By a rhodium-platinum resistance thermometer, and by the use of methods designed to get over the difficulties arising from the presence of air in the hydrogen, the boiling-point was determined as $-246°$ C. A constant volume hydrogen thermometer working under diminished pressure has given $-252°$ C. The pure platinum resistance thermometer gave $-238°$ C. A. D.

1490. *Tempering of Glass.* **L. Marchis.** (Journ. de Physique, 8. pp. 193–206, 1899.)—The author verifies experimentally one of the foundations of Duhem's theory of the secular changes of glass and the displacement of thermometer zeros. He shows, among other consequences, that if instead of producing an abrupt cooling from T_2 to T_0 during a disturbance, the thermometer is maintained for some time at a lower temperature, T_3, the glass is tempered to the same extent as it would be by a disturbance at the temperature T_3. E. E. F.

1491. *Some Applications of Molecular Volumes.* **A. Leduc.** (Annal. Chim. Phys. 17. pp. 173–196, 1899.)—By molecular volume is here meant the function ϕ which occurs in the author's form of the characteristic for gases, viz.—

$$Mpv = RT\phi,$$

wherein M is the molecular weight, T the temperature on a scale starting from $-273{\cdot}2°$ C., and R a constant for all gases. This function, determined empirically by the study of a certain number of gases in particular conditions, was generalised by means of the principle of corresponding states. (See 1898, Abstracts Nos. 300 and 383.) Assuming its absolute correctness, the author applies it to test the exactness of various determinations of the densities and specific volumes of certain saturated and non-saturated vapours, viz., isopentane, ether, carbon disulphide, and water. He then applies it to the case of vapours that are anomalous by reason of dissociation or polymerisation, especially chlorine, nitrogen-peroxide, and acetic acid, and concludes that, though Natanson's experiments on chlorine cannot be said to fully confirm Gibbs' theory of dissociation, they amply justify it; but he insists on the necessity of calculating the density of a gas or vapour by his formulæ and not directly from its molecular weight. In a postscript he gives 15·88 as the atomic weight of oxygen. R. E. B.

1492. *Maxwell's Theorem.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 214–216, 1899.)—This purports to be a generalised demonstration of the theorem that the total area of the cycle formed of an actual and the corresponding theoretical isothermal is zero: it starts from Gibbs' equation. R. E. B.

1493. *Modification of Van der Waals' Equation.* **L. Boltzmann** and **H. Mache.** (Wied. Annalen, 68. 2. pp. 350–351, 1899.)—The modified formula is—

$$\left(pT+\frac{a}{v}\right)\left(v-\tfrac{1}{3}b\right) = rT\left(v+\tfrac{2}{3}b\right)$$

It has the advantage of yielding values for p of the order of magnitude

$$\left(v-\tfrac{1}{3}b\right)^{-1}$$

i.e., infinite, when v is nearly equal to $\tfrac{1}{3}b$. The theoretical results are compared with Amagat's values for carbonic acid. The agreement is not very satisfactory, especially for the lower temperatures, but is in any case better than that obtained by Van der Waals. E. E. F.

ELECTRICITY.

1494. *Electrification of Air.* **Kelvin, M. Maclean,** and **A. Galt.** (Phil. Trans. 191. pp. 187–228, 1898.)—A description is given of a series of experiments on the electrification of air and other gases, in which three different methods were employed: (1) Observation of electrification of the substance receiving the electricity equal and opposite to that taken by air; (2) observation of electricity of a hollow metal vessel into which electrified air is introduced, or from which electrified air is removed; (3) observation of the electricity taken out of air by the electric filter. An account of the results obtained by method (1), in which air and other gases become electrified when blown in bubbles through water or solutions of salts, has been formerly published. The electrification of the air was negative. By method (2), experiments here described have determined approximately in absolute measure the total quantity of electricity in a given mass of electrified air; and it has been found that the greatest electrification which could be communicated to a large quantity of air by needle-points supplied with electricity from an electric machine, was $3{\cdot}7 \times 10^{-4}$ c.g.s. electrostatic units per cc. While this is the greatest electric density obtained by the authors with needle-points, a density of 22×10^{-4} c.g.s. electrostatic unit was obtained by an electrified hydrogen flame.

In the first experiments with method (2) the apparatus consisted of a metal can, 48 cm. high and 21 cm. in diameter, supported by paraffin blocks, and connected to one pair of quadrants of a quadrant electrometer. It had a hole at the top to admit the electrifying wire, which was 531 cm. long, hanging vertically within a metallic guard tube, which latter was connected to the other pair of quadrants of the electrometer, and to its sheath and to a metallic screen surrounding it. During the experiment one terminal of the electric machine is connected with the guard-tube and the other with the electrifying wire, which is tipped with needle-points or tinsel, placed nearly in the centre of the can. The can is temporarily connected to the sheath of the electrometer. The electric machine is then worked for some minutes so as to electrify the air in the can. As soon as the machine is stopped the electrifying wire is lifted clear out of the can. The can and the connected quadrants are disconnected from the sheath of the electrometer, and the electrified air is very rapidly drawn away from the can by a blowpipe bellows, arranged to suck. This releases the opposite kind of electricity from the inside of the can, and allows it to place itself in equilibrium on the outside of the can, and on the insulated quadrants of the electrometer in metallic connection with it. It was found that one needle and four minutes' electrification gave as great electrication as could be obtained. A modification for quickly removing the air from the can was adopted, and the greatest electric density found for the air was, as stated above, $3{\cdot}7 \times 10^{-4}$. Other experiments on electrification of air, by water-jet, and by an insulated water-dropper at different potentials, are described. On raising the temperature of the air the electrification diminished.

Air, and other gases, were shaken up with water, and with solutions of different substances, and the electrification produced in the gases measured. The largest value obtained was that in the case of coal-gas from a pressure cylinder shaken up with water, in which the quantity of electricity found in the gas per cc. was (in c.g.s. electrostatic units) $0{\cdot}42 \times 10^{-4}$ neg.

Different gases were electrified by needle-points and flames, the gases being drawn through an electric filter consisting of a block-tin pipe with two brass gauges and one plug of cottonwool between them. When the air in a glass cylinder was electrified by six needle-points the remarkable result was found that short times of electrification at 5,000 volts gave greater values as indicated by electrometer and filter than longer times of electrification. Similar results were obtained with carbonic acid gas, a nearly perfect annulment of the electrification by ten minutes of the electrified needle-point in carbonic acid, and by five minutes in air, being noticed. The explanation suggested is the production of a conductive quality in the gas by continued electric disruptive action.

The results of tests of the efficiency of various filters are given.

The current of electricity from an electrified needle placed in the centre of a jar coated inside with strips of tinfoil was measured, first with different pressures of the air, the potential of the needle being constant, and next with constant pressure of the air while the potential of the needle was varied. In the first case the current through air from needle to metal of jar became greater as the pressure of air became less, down to the lowest pressure observed, viz., 4 cm. In the second case, while the current increased regularly for increasing potential of the needle, the current with the same air-pressure is greater for negative than for positive electrification. A certain minimum potential of the needle is necessary before any current is shown. Also it was found that air at a given pressure was electrified to a greater extent by a certain potential of the needle than by other potentials higher or lower. J. J. S.

1495. *Break-up of a Discharge.* **H. Abraham.** (Comptes Rendus, 128. pp. 991–994, 1899.)—Experiments showing how a high tension deflagrator discharge, with flame, may be broken up into intermittent flame discharges by lowering the inducing current, or by blowing air through the flame. In the latter case the discharges are equal, and their frequency is proportional to the strength of the inducing current. A. D.

1496. *Electrolytic Actions near Crookes Tubes.* **H. Bordier and Salvador.** (Comptes Rendus, 128. pp. 1511–1512, June 19, 1899.)—This investigation was undertaken to explain the effects of Crookes-tube discharges on the skin, which have been attributed to X-rays. It is found that an electromotive force of polarisation is set up between two plates of copper or of zinc immersed in a solution of the sulphate of the same metal, the whole being contained in a tube placed near the excited Crookes tube. The electromotive force persists even after the tube of liquid has been screened from X-rays; its amount diminishes with increased distance from the Crookes tube, and its direction corresponds with that of a discharge between the anode and the kathode, the circuit of which is completed by the liquid. On increasing the resistance of the Crookes tube, the electrolytic effect becomes more marked, although the intensity of the X-rays is smaller. The authors attribute the effects on the skin to these electrolytic actions. J. L. H.

1497. *Velocity of Electric Waves.* **G. V. MacLean.** (Phil. Mag. 48. pp. 115–131, July, 1899.)—Electric waves about 6 metres long are generated by an oscillator, and detected by a resonator of exactly the same form and size, and which is really a specially devised coherer. By reflection, stationary waves are obtained and their length measured by detection of the nodes and loops. The period of the waves was determined by photography of the spark. The result obtained is: $v=2{\cdot}991\times10^{10}$ cm. per sec., or about 186,365 miles per sec. in air. E. H. B.

1498. *Velocity of Electric Waves along Wires.* **C. Gutton.** (Comptes Rendus, 128. pp. 1508–1511, June 19, 1899.)—Using a Branly tube as a detector, the author compares the velocities of propagation of electric waves along wires and in the air. Within the limits of the errors of observation, viz., about 1 in 200, the two velocities appear the same. E. H. B.

1499. *Absorption of Electric Waves and Electroluminescence.* **H. Kauffmann.** (Zeitschr. Phys. Chem. 28. pp. 673–707, 1899.)—The author makes many generalisations from the work of Drude on abnormal absorption of electric waves 75 cm. long, and his own observations on luminescence of vapours under the influence of Tesla waves: the principal are as follows:—

Abnormal absorption is due to the presence of a weak bond in the molecule, such as is indicated by ready decomposition, oxidation, reduction, &c. For 75 cm. waves a maximum of absorption accompanies a medium degree of weakness. Abnormal absorption may be predicted; the determining groups, besides OH, are NO_2, N_2O in azoxy bodies, CO.CO, NH in aromatic amines and hydrazo bodies, CH : N : CH, &c.

With Tesla waves, aromatic substances luminesce far more than aliphatic ones: OH and NH_2 have a determining influence, while Cl, Br, NO_2 and $C_2H_3O_2$ oppose luminescence; alkalisation is indifferent. The cause of luminescence is ascribed to a tendency of the benzol ring to pass over into the quinone form.

B. B. T.

1500. *Transparency to Hertzian Waves.* **G. Le Bon.** (Revue Scientif. 11. pp. 513–526, 1899.)—The shortest Hertzian waves yet produced are of 5 mm. wave-length. In Hertz's work the difficulty was to produce waves which could be detected. Nowadays the difficulty is not in producing Hertzian waves, but in avoiding their production. Even to touch anything is enough to produce these waves. When an induction coil is used, the spark must be very short; the frequency is then high, the colour of the spark is different, and one pole of the coil can be touched without pain. The variations of conductivity in a coherer are only an exaggeration of what must occur in every circuit-wire clamped in by binding screws, upon the production of any spark in its neighbourhood. This can be readily shown by measuring the resistance of a pile of discs of iron, bismuth, or aluminium, before and after passing a spark near it. If the discs be of different metals, shocks will bring the resistance up to 30,000 ohms, and a spark will suddenly reduce this to 3 ohms. Copper wire does not produce this effect; if iron wire had been more generally used, Ohm's law might not have been discovered, for making and breaking the circuit itself makes sparks sufficient to produce the disturbing effect referred to. And more than this, the neighbourhood of copper seems to prevent this effect, so that a pile of alternate discs of copper and aluminium obeys Ohm's law.

Metals are apparently not nearly as opaque to Hertzian waves as was at first thought; but if the enclosure be perfect the waves do not get through. The apparent transparency is due to the waves getting through chinks or round the metal; but if there be no chinks, a thickness of $\frac{1}{100}$ mm. is as effectively opaque as one of 2 mm., and forms a perfect screen, so that waves cannot even travel down a metallic rod into the interior of a perfectly closed box. A chink is much more effective in allowing rays to pass through than a much more considerable series of apertures; and metallic gauze is very nearly as opaque as a plate.

The length of the waves makes them turn round obstacles with great facility: which accounts for the apparent partial transparence of metallic mirrors.

Non-metallic substances have been considered to be perfectly transparent. But do the Hertzian waves come through a hill or round it? 12 cm. of Portland cement are partially opaque, 30 cm. wholly so. Dry sand is almost completely transparent, wet sand much less so. Freestone is much less opaque than cement; but it becomes more so when wet. These bodies are far more transparent for Hertzian waves than for light, but the transparency varies from one body to another, decreases as the thickness increases, and increases when the bodies are wet. The waves therefore come round, not through, a hill.

If we put together: (1) a 25 cm. induction coil; (2) a spark-gap and two Leyden jars; (3) a solenoid coil connecting the two Leyden jars; (4) a large coil of copper wire; (5) two wires leading from the ends of the solenoid (3), one to the lowest point of the coil (4), the other to a point of the same to be found by trial and error; (6) a wire leading from the top of (4), and with a free tip; then on setting (1) in action, sparks pass in (2), and an oscillating current in (3), which current is partly taken through (4), and there affected by self-induction, so that a large "brush" is formed at the tip of (6), and this brush traverses dielectrics freely without deviation (therein differing from the ordinary electrostatic brush), and in the dark can be seen to do so. This bombardment ruins a Geissler tube as if it had been riddled with small holes; but the explanation of the phenomenon is still to be found. The photo-plate shows that the phenomenon extends to a considerable distance beyond the visible glow of the brush. At two metres distance a Geissler tube will glow up. The whole field of the brush seems to become a rapidly oscillating electrostatic field. A distribution-table within it at some distance, when the induction coil had a 50 cm. spark actuated by a 110 volt current, was covered with sparks; the wires fused and short-circuited, and a conflagration was started. If this brush could be concentrated upon a warship, it would be caught up by the electric wires and would cover them with sparks which would soon cause an explosion. The same effect could no doubt be produced upon ammunition stores, and even the contents of soldiers' cartridge belts. A. D.

1501. *Capacity.* **I. I. Borgman and A. A. Petrowski.** (Comptes Rendus, 128. pp. 1153–1155, 1899.)—Columns of liquids, good conductors, have the same capacity as equal columns of mercury. Columns of liquids, bad conductors, have the same capacity as mercury columns when their heights are very small, but the capacities become less in proportion as the heights increase, and tend asymptotically towards limiting values. Columns of liquid insulators (anhydrous ether, xylol, solution of alcohol in ether up to 22 per cent. alcohol) have no capacity. The capacity of a tube containing a rarefied gas increases as the pressure diminishes, up to a certain limit. The capacity of a series of Geissler tubes or of tubes without electrodes is less than the sum of the individual capacities; and the increase in capacity per single tube added to the series is less the greater the number of tubes already in series. If an insulated Geissler tube be brought near another Geissler tube, the capacity of the latter is not affected; but if one of the terminals of the former be earthed, the capacity of the latter is greatly increased; and similar results are observed with electrodeless tubes if the one end of one of them be surrounded by tinfoil paper, and this paper be put to earth. A. D.

1502. *Direct Measurement of Electrical Quantity.* **R. Blondlot.** (Comptes Rendus, 126. pp. 1691–1695, 1898.)—At the centre of a long horizontal solenoid is freely suspended a circular coil of a few turns, the solenoid and movable coil being connected in series by means of mercury cups. The earth's field having been compensated, the position of equilibrium of the movable coil when a current is sent through the apparatus is that in which its plane is normal to the axis of the solenoid. When slightly disturbed from this position, the coil will oscillate, the period being given by $T=2\pi\surd\{I/4\pi n A i^2\}$, where I is the moment of inertia of the movable system, n the turns per cm. length of solenoid, A the total area embraced by the various turns in the movable coil, and i the current. From this it follows that $iT=\sqrt{\frac{I\pi}{nA}}=\text{constant}$, a result which enables us to measure directly in electromagnetic measure the quantity passed through the apparatus during any given time. This principle has been applied to the construction of electric meters: the movable coil carries a long contact arm, which periodically closes the circuit of a small electromagnet; the latter attracts an armature attached to one end of a straight flat spring, which gives the movable coil a fresh impulse by striking the contact arm. The total quantity which passes through the meter is directly proportional to the number of oscillations (or the number of times the circuit of the electromagnet is closed by the contact arm), and this number is suitably recorded by an appropriate counting mechanism. A. H.

1503. *Electrolytic Conduction without Electrodes.* **H. Behn-Eschenburg.** (Zeitschr. Elektrochem. 5. pp. 402–404, 1899.)—A continuous non-conducting trough is put round the iron core of a transformer, and is filled with a solution of an electrolyte. The trough constitutes an elementary coil, in which the varying magnetic field of the transformer induces currents. The intensity and distribution of these currents is studied by means of a voltmeter connected to exploring electrodes, and the induced E.M.F is measured by a voltmeter in circuit with an auxiliary coil on the transformer. The experiments carried out with this apparatus show that electrolytic conduction is subject to the same laws as metallic conduction. E. E. F.

1504. *Conductivity of Electric Arc and Metallic Oxides.* **W. B. Burnie** and **C. A. Lee.** (Electrician, 43. pp. 75–79, 1899.)—The authors point out an analogy between the conductivity of the arc and certain metallic oxides. The first point of similarity is that many of the metallic oxides possess, like the arc, what may be called a "negative resistance," that is to say, for certain current values any increase in the current is accompanied by a decrease in the potential difference, or the differential coefficient of potential difference with respect to current is negative. The authors then consider under what circumstances the resistance of a conductor can so depend on temperature that this can be the case; or since the temperature is a function of the watts radiated they find the necessary relation between these and the resistance.

These conditions are—

$$\text{either } \frac{dR}{dW} > \frac{R}{W} \text{ or } \frac{dR}{dW} < -\frac{R}{W}$$

where R is the resistance of, and W the watts radiated by, the conductor. That is, the resistance must either increase or decrease very rapidly with regard to the watts radiated.

The first of these two conditions would give a perfectly stable state, a definite current for a definite potential difference. The second condition gives unstable equilibrium and is the condition fulfilled by the oxides and also by the arc if that has only resistance. In order to obtain stability in these cases it is necessary to put a resistance in series with the conductor the value of which is greater than the "negative resistance" of the conductor.

In regard to the similarity between the nature of the resistance of these oxides and of the arc, the authors investigated whether the "negative resistance" of the oxide is due to a varying back E.M.F. or merely to changes of actual resistance due to changes of temperature. This was done by superposing on the continuous current a small alternating current, and determining certain points on the potential difference and current curves, and it was found that if any E.M.F. existed it was less than $\frac{1}{500}$ of a volt. In consideration of the analogy between the behaviour of the oxides and the arc, it seems likely that by experimenting with currents of a much higher frequency the arc may be shown to be merely a simple resistance; but for conclusive results the frequency must be much higher than the normal frequency of alternating currents produced by a hissing arc. E. C. R.

1505. *Copper Temperature-Coefficient.* **R. Appleyard.** (Elect. Rev. 44. p. 588, 1899.)—Clarke, Ford, and Taylor's tables have the merit of fitting their observed figures, and may replace Matthiessen's, but justice is not done by the paper to the logarithmic law, owing to a possible error in the choice of the logarithmic rate of interest. The mean of all the rates calculated from every alternate pair of observation-points throughout the "observed" curve should be taken, whereas Clarke, Ford, and Taylor have taken probably the first and last points only. For cable work the straight-line law is quite as accurate as our knowledge of the temperature. [See 1899, Abstract No. 1170.] M. O'G.

1506. *Polarisation in Solutions of Alkaline Sulphates.* **H. Jahn.** (Zeitschr. Phys. Chem. 29. pp. 77–88, 1899.)—The method is similar to that described Zeitschr. Phys. Chem. 26. 385, 1898 (see 1898, Abstract No. 302). Values are given for Na_2SO_4, Li_2SO_4 and $(NH_4)_2SO_4$ at 0° and 40°, and agree well with logarithmic formulæ of the type :—

Polarisation = A + B log (current), where A and B are constants. B. B. T.

1507. *Clark Cells.* **E. Cohen.** (Zeitschr. Phys. Chem. 28. pp. 723–736, 1899.)—The author has arrived at the same conclusion as Callendar, Skinner, and Griffiths, *i.e.*, that the fortuitous variations of the Clark cell are due to the presence of crystals in the solution. R. A.

1508. *Callendar's Electrical Recording Apparatus.* (Elect. Rev. 44. pp. 582–583, 1899.)—This is a description of Callendar's recording apparatus, which may be described as an automatic bolometer. W. G. R.

1509. *New Resistance Box.* (Electrician, 42. pp. 837–839, 1899.)—This is a description of a new type of resistance box due to Messrs. Gambrell Bros. The resistances are wound on rods which are drawn through holes at the side of the box, and in certain positions contact is made by rings on the rods and brass sleeves let into the holes. W. G. R.

1510. *Oscillographs.* **A. Blondel.** (Ind. Élect. 8. pp. 137–144, 1899.)—The author briefly reviews the history of oscillographs from his first proposal in 1893, and points out the principles of their working and the conditions to be fulfilled. The latter are in short as follows: (1) Short natural period; the frequency of vibration must be at least fifty times that of the subject of examination; (2) damping regulated to the critical value to give aperiodicity; (3) negligible self-induction; (4) absence of hysteresis and eddy currents; (5) high sensibility; (6) brightness of the spot of light. The bifilar and soft iron types alone are important. The former consists of a coil composed of two wires stretched in a strong magnetic field and supporting a mirror at their centre. In the latter a very small soft iron needle carrying a mirror is suspended in a strong magnetic field, and the coils are fixed on either side of the needle. In each case the whole of the moving parts are immersed in a bath of castor oil, the viscosity of which is adjusted by varying the temperature to the critical condition of damping. The construction of a double oscillograph of the soft iron type, and of the subsidiary apparatus for illuminating the mirrors and observing the curves, is described in detail, with numerous illustrations. The natural frequency of vibration of the needles is about 6,000 per second, and the curves for a forced frequency of 50 per sec. are accurate to 1 per cent. To obtain the time ordinate, a disc with radial slits rotates in front of a vertical slit, in synchronism with the applied frequency; the vertical slit is illuminated either with an arc or with an incandescent filament parallel to the slit. The screen is of ground glass in a blackened tube; but a telescope may be used to view the image of the curve directly, or a photographic plate may be substituted and exposed by an instantaneous shutter. The synchronous motor consists of a light flywheel carrying strips of soft iron on the circumference and rotating before two electromagnets excited by the current under examination. (See also 1899, Abstract No. 829.) A. H. A.

1511. *New Method of Using Galvanometers.* **Féry.** (Comptes Rendus, 128. pp. 1392–1393, June 5, 1899.)—On account of the great sensibility that can be given to galvanometers with a moving coil, when the controlling force due to torsion is very weak, the zero keeps shifting and the deviations become uncertain, thus preventing the ordinary deflection methods for determining the current through them being used. The author proposes to measure the current by shunting the coil of the galvanometer with a low resistance and noting the speed at which it moves.

The author works out the theory mathematically and arrives at the following result when the moment of inertia of the coil is very small:—

$$E=K\left(v_1+\frac{v_0+v_2}{2}\right),$$

where E is the potential difference at the terminals of the galvanometer, v_0, v_1 and v_2 the respective speeds of the coil before, during, and after the passage of the current. This method is analogous to those employed in calorimetry, where the rate of heating is corrected by the observation of the rate of cooling before and after the measurement. The apparatus used by the author had a coil of 30 ohms, it weighed about 3 grams, and was suspended by a silver wire 0·032 mm. diam. and 60 cm. long. A difference of potential of 0·000001 volt at its terminals, giving a current of 0·00000003 ampere in the coil, produced a corrected speed of the spot of light of 6·75 mm. per minute. Experiment shows the absolute proportionality of the speeds to the currents for speeds varying from 6 mm. to 600 mm. per minute.

E. C. R.

1512. *Kathode Rays in Investigating Alternating Currents.* **E. E. Seefehlner.** (Elektrotechn. Ztschr. 20. pp. 120–121, 1899.)—A method is described for studying an alternating current by superposing on its field the field of a regular alternating current of the same frequency, at 90° to the former, and studying the resultant deflecting action upon kathode rays by means of the luminous figures produced. A. D.

1513. *Measurement of Frequency of Alternating Currents.* **C. Kinsley.** (Phys. Rev. 8. pp. 244–249, 1899.)—A vibrating iron or steel strip is loaded with a non-magnetic rider, and the position of this rider varied until its natural period of vibration synchronises with that of the alternate current to be measured. The vibration of the iron strip is produced by an electromagnet, through which the alternating current is passed.

The equation for the frequency is—

$$\frac{1}{p^2} = Fmr^3 + K,$$

where p is the frequency of the alternating current, m the mass of the rider, r its distance from the fixed end of the strip, and F and K constants depending on the iron or steel employed and on the dimensions of the strip. The author claims that much greater accuracy can be obtained by this method than by the method of altering the length of the vibrating strip, as in Campbell's "frequency teller," and gives a case of measurement of a frequency of 133 ∿, the length of the strip being 5·35 cm., where it was found easily possible to arrange the strip so that a change of 0·25 per cent. in the frequency required a change of 1 cm. in the position of the rider. E. C. R.

1514. *Alternate-Current Frequencies.* **J. Zenneck.** (Wied. Annalen, 68. 2. pp. 365–368, 1899.)—The author describes a simple and elegant method for exactly controlling the frequency of an alternator. The alternate current is made to produce a rotary field. The kathode beam of a Braun tube is exposed to this field, and its end is thus made to describe a circle. The circle is interrupted twice at every revolution in such a manner as to leave only two dots at the ends of a diameter. This is done by means of a tuning-fork tuned to unison with the normal frequency, or at least to a multiple of that frequency. While the frequency remains the same, the dots always appear in the same place. But as soon as it changes, the dots advance in one direction or the other along the circumference of the circle. A difference of 0·1 per cent. makes the spots travel round the circle in 10 seconds, and that is easily seen. E. E. F.

1515. *Thermo-electromotive Forces.* **C. Liebenow.** (Verh. Deutsch. Phys. Gesell. 1. pp. 74–80, and 82–87, 1899.)—Take a block of metal, 1 c. cm., supply its upper surface with heat and withdraw heat from its lower: maintain a difference of 1° between these two surfaces. Further, connect both surfaces by an imaginary conductor which neither develops E.M.F. nor offers electrical resistance. Assume that in this conductor a current passes when the heat-flow takes place. Let W be the external work, H the heat transmitted, and τ the absolute temperature; then for the maximum value of W we have

$$dW=(H/\tau)\,d\tau.$$

Then if I be the current strength between the two surfaces and dE the E.M.F., we have $dW=I.dE$; and if R be the whole electrical resistance between the two surfaces, we have also $I=dE/R$. Further if L be the conductivity of the block for heat, $H=L.d\tau$. From these equations we find

$$(dE)^2=RL\frac{(d\tau)^2}{\tau}$$

But R and L must both be measured on the same system of units; and as 1 Watt-second = 0·24 gramme calorie, if the equation is to be read in electrical units, we must make it

$$(dE)^2=\frac{R}{\tau}\cdot\frac{L}{0\cdot24}\cdot(d\tau)^2$$

or—

$$\frac{dE_{max}}{d\tau}=\pm 2\cdot04\sqrt{\frac{RL}{\tau}}.$$

For copper at 15° C., $L=0\cdot8$ and $R=0\cdot000001635$; whence $dE/d\tau=\pm0\cdot0001375$ volt per degree Centigrade, a value which is independent of the dimensions of the copper, and represents the maximum E.M.F. attainable in copper through the transmission of heat under these conditions. The corresponding value for iron is 154·4 microvolts per degree. The difference between iron and copper then works out as $154\cdot4-137\cdot5=16\cdot9$ microvolts per degree C. Similarly for other pairs of metals. Differences as regards properties along different axes appear to have the effect of preventing the complete conversion of the heat passing into the energy of current: and this may have the effect of making the actual current produced—*e.g.*, with bismuth in the couple—differ greatly from the possible maximum as calculated above.

Now let i be the strength of any current passing in the conductor, and h the quantity of heat passing any cross section per second. Then from the preceding, $h = 0{\cdot}24.i\tau.dE/d\tau$; and for an isothermal system of conductors collecting current through different substances to one point, at that point the heat developed per second will be—

$$\Delta h = 0{\cdot}24\tau.\Sigma i.dE/d\tau.$$

If there is a drop of temperature in a conductor, in an element of length in which the current i enters at τ and leaves at $\tau + d\tau$, the heat developed per second is $dh = 0{\cdot}24i.\tau.\left(\frac{1}{\tau}\cdot\frac{dE}{d\tau} + \frac{d^2E}{d\tau^2}\right)\cdot d\tau$ whereof the Thomson effect is—

$$dh' = 0{\cdot}24i.\tau.\frac{d^2E}{d\tau^2}\cdot d\tau.$$

In bad conductors R is large and L usually relatively small. In glass, for example, the value of $dE/d\tau$ is much greater than in metals: compare tellurium, selenium, and many crystals with dissimilar axes. Antimony or bismuth, crystallised, with a wire connecting terminal and lateral surfaces, give a current so long as the crystal, heated in a lamp, is hotter on the exterior than internally. In tourmaline, which is a good insulator, the potential differences are very high. The same cause would account for the setting up of considerable potential differences in air through which heat is being conducted.

Discussion of the different data of different observers leads to the conclusion that in metals the flow of heat is opposed to the flow of positive electricity. The Thomson effect leads to the same conclusion: this only appears where $dE/d\tau$ alters with the value of τ. In antimony $dE/d\tau$ has the greater value at the colder end, so that the current flows opposite to the flow of heat. In alloys the resistance is increased more than the heat-conductivity diminishes, so that $dE/d\tau$ is on the whole greater in these than in the component metals. In non-metals the flow of heat and the E.M.F. are in the same direction: tellurium 500, selenium 800 microvolts, and the warmer ends are negative. When non-metallic bad conductors are rubbed with amalgam, they are heated and the heated surface becomes negative at the amalgam. When two non-conductors are rubbed together, the one for which RL has the greater value becomes positive (frictional electricity). When two pieces, one warmer, one colder, of the same substance are rubbed together, the warmer one becomes negative. A. D.

1516. *Thermo-dynamics of Thermo-couples.* **C. Liebenow.** (Wied. Annalen, 68. 2. pp. 316–324, 1899.)—The author postulates a direct connection between heat and electricity of a kind such as to necessitate the production of thermo-electric energy whenever heat passes from a point at a higher to a point at a lower temperature. This assumption leads to another, to the effect that every electric current is necessarily accompanied by a thermal current, and the surprising corollary results that an E.M.F. in a metal may force a stream of heat to go against the slope of the heat curve from a lower to a higher temperature. This means that the thermo-electric phenomena are reversible. For the details of this interesting and promising attempt to solve a complex problem, the original paper should be consulted. But it may be said that the author succeeds in arriving at figures with regard to the ordinary thermo-electric current, as well as the Thomson and Peltier effects, which are borne out by experimental data. E. E. F.

1517. *Wehnelt Interrupter.* **A. Le Roy** (Comptes Rendus, 128. p. 925, 1899); **P. Bary** (Comptes Rendus, 128. pp. 925–927, 1899); **L. Kallir** and **F. Eichberg** (Zeitschr. Elektrotechn. Wien, 17. pp. 184–188, 1899; **Satori** (Zeitschr. Elektrotechn. Wien, 17. pp. 218–219, 1899); **P. Villard** (Paris Soc. Franc. Phys. Bull. 130. pp. 4–5, 1899); **E. Thomson** (Elect. World and Engineer, 33. p. 579, 1899); **A. A. C. Swinton** (Electrician, 43. pp. 332–333, June 30, 1899); **C. T. Child** (Elect. Rev. N.Y. 34. p. 295, 1899); **E. Thomson** (Elect. Rev. N.Y. 34. pp. 295 and 311, 1899); **E. W. Caldwell** (Elect. Rev. N.Y. 34. p. 311, 1899); **G. T. Hanchett** (Elect. World and Engineer, 33. pp. 436–437, 1899).—These papers describe various forms of the Wehnelt interrupter, and include a careful examination of the phenomena. The most important observations are those of Kallir and Eichberg, who apply a stroboscopic method to determine the time-interval of interruption, and find it to be of the order of 0·0005 sec.; stroboscopic observations are further made, using the platinum-point first as anode and then as kathode: the time-interval with a point anode is about double that corresponding to a point kathode. Spectroscopic observations of the glow in each case are also described.

The papers of C. Child, P. Villard, A. Le Roy, G. Hanchett, P. Bary, and Satori are mostly concerned with electrical measurements made upon circuits containing a Wehnelt form of interrupter. Elihu Thomson, E. Caldwell, and Campbell Swinton describe modifications of the apparatus, in which the electrodes are separated by a glass partition having a small aperture. The interruption in the electrolytic circuit takes place in this aperture instead of at one of the electrodes. R. A.

1518. *Wehnelt Interrupter.* **J. Carpentier.** (Comptes Rendus, 128. pp. 987–988, 1899.)—It was observed by Armagnat that the potential difference necessary to produce the required intermittence depends to some extent upon the temperature of the dilute acid, and that an interrupter works at less potential difference when the electrolyte is hot than when it is cold. Carpentier therefore surrounds the containing vessel with an air jacket. The electrolyte is poured in at 80° C. or 90° C., and is afterwards maintained at that temperature by the heat generated in the process of working. R. A.

1519. *Wehnelt Interrupter.* **H. Armagnat.** (Comptes Rendus, 128. pp. 988–990, 1899.)—The interruptions produced by the ordinary arrangement of a Wehnelt interrupter and induction coil are not such as to produce reversals in the primary circuit; but oscillatory currents can be obtained by connecting a condenser between the terminals of the interrupter. A 1-microfarad condenser used in this way with a coil giving a 25 cm. spark produces effects similar to those observed with an ordinary make-and-break apparatus. The author shows that in order to explain the oscillatory character of the current in the latter case, it is not necessary to invoke the idea of "electrolytic capacity," but that it is sufficient to assume that at the contact surface of the anode with the electrolyte there exists a resistance which rises and falls with the rising and falling of the local temperature, *i.e.*, that the local resistance is a function of the current. R. A.

1520. *Theory of Wehnelt Interrupter.* **H. T. Simon.** (Wied. Annalen, 68. 2. pp. 273–293, 1899.)—The author claims to have formulated a complete theory of what is erroneously termed the "electrolytic" interrupter. According to him the effect is altogether Joulean, and there is no electrolysis, though there may be chemical disassociation by heat. In Wehnelt's original form of the interrupter there is no considerable resistance to the current, except at the platinum point. There the temperature increases very rapidly at make, and leads to the formation of a gaseous layer which interrupts the current. A mathematical treatment of these conceptions leads to the following formula governing the action of the interrupter:—

$$T=\frac{3}{2}\frac{L\omega}{k}+\frac{C_1 k}{E^2\omega}+C_2,$$

where T is the time of interruption, L the inductance of the circuit, E the E.M.F., ω the anode surface, k the specific resistance of transition, and C_1 and C_2 constants. This formula enables the observer to determine beforehand the E.M.F. and inductance required for any given period of interruption. If the resistance and inductance are constant, the relation between the period and the E.M.F. is of the form—

$$T = A + \frac{B}{E^2}.$$

This formula, in particular, is very closely borne out by experiment. E. E. F.

1521. *Wehnelt Interrupter.* **P. Spies** and **A. Wehnelt.** (Verh. Deutsch. Phys. Gesell. 1. pp. 53–59, 1899.)—The authors describe the general effects produced by the interrupter in working, and give references to the following papers: Koch and Wüllner (Wied. Ann. 45. pp. 759 and 773, 1892); Hoho and Lagrange (Lumière Électrique, 52. p. 113, 1894); Richarz (Wied. Ann. 39. pp. 71–72, 83–85, 1890; 47. pp. 579–582, 1892; 63. pp. 261–267, 1897); A. Wehnelt (Elekt. Zeitschr. 4. p. 76, 1899). In summarising the phenomena it is shown that (1) if the applied volts are increased the current increases, the rate of interruption increases, and the current-density increases; (2) if the anode surface is increased the current is increased, the rate of interruption is diminished, and the current-density is diminished; (3) if the self-induction of the circuit is increased the current is diminished, the rate of interruption is diminished, and the current-density is diminished. Some discussion has arisen as to whether the diminution in the rate of interruption with increase of self-induction is due to the corresponding diminution of current, or whether it is an independent effect of "electrolytic capacity." When two electrodes dipping into an electrolyte are connected to the ends of a coil into which a magnet is suddenly thrust, a quickly damped oscillatory current is set up in the circuit. The initial current causes a gaseous layer to form about the electrodes; the layer quickly vanishes, but not before the return-current has made its appearance: the layer may therefore be regarded as behaving like the dielectric of a condenser. The "electrolytic capacity" thus introduced is held to contribute to the oscillatory character of the discharge. R. A.

1522. *Effects of Temperature and of Circular Magnetisation on Longitudinally Magnetised Iron Wire.* **F. H. Pitcher.** (Phil. Mag. 47. pp. 421–433, 1899.)—The iron wire specimen, which was 0·127 cm. in dia. and 26·1 cm. long, was magnetised by a solenoid wound on a thin brass tube about 70 cm. long and 2·23 cm. in external dia. The intensity of magnetisation was determined from the deflection of a magnetometer, the direct effect of the solenoid being compensated by a balancing coil.

The broadside-on position was adopted for the test, as this seemed to give better agreement with ballistic measurements than the end-on position. The wire was heated and at the same time circularly magnetised by a current flowing through it. In order to separate the effects due to heat and circular magnetisation, three sets of observations were taken: (1) in a very high vacuum; (2) in air at atmospheric pressure; (3) in a current of water. As regards the effect of heat, the well-known decrease of permeability in strong fields was observed with rise of temperature; it was found that the point of demagnetisation—which occurred in the neighbourhood of 750° C.—was not absolutely sharp, the **I–H** curve after descending rapidly changing its direction and descending much more slowly until it reached the **H** axis. With regard to the effect of circular magnetisation, it was found that for weak longitudinal fields the effect was strongly marked, the corresponding longitudinal **I** being greatly reduced, but that as the field increased in intensity the circular magnetisation produced less and less effect. A. H.

1523. *Nickel Steel.* **C. E. Guillaume.** (Paris Soc. Franc. Phys. Bull. 123. pp. 3–5, 1898.)—The author describes the properties of nickel steel referred to in Abstract No. 1115 (1898). He also discusses the various phenomena from the point of view of variations in the relative proportions of combined and dissolved material, as against that of polymerisation and depolymerisation of molecules consisting of mixed atoms of iron and nickel. A. D.

1524. *Magnet Steels.* **F. Osmond.** (Comptes Rendus, 128. pp. 1513–1516, June 19, 1899.)—In order that a cast steel may make a usable permanent magnet it is necessary and sufficient that the points of transformation be respectively below 350° and above the lowest temperature to which the metal will be submitted (see Abstract No 1203, August, 1899). This condition can be realised (1) by tempering; (2) by adding certain metals, such as manganese, nickel, chromium, or tungsten. The latter, or self-hardening steels, are investigated in the present paper. They are hardened by cooling from a temperature above their point of transformation during heating, and softened on bringing their temperature below that of transformation. The steels investigated contain varying proportions of manganese, nickel, and carbon. They are of interest chiefly because they require no tempering, and their magnetic properties are constant throughout their mass. J. L. H.

1525. *Low Temperatures and Magnetic Properties.* **F. Osmond.** (Comptes Rendus, 128. pp. 1395–1398, June 5, 1899.)—Certain nickel steels and manganese steels show no magnetic properties until they have been exposed to very low temperatures. The phenomenon is analogous to the lowering of the freezing-point of a liquid by dissolved substances. When certain substances are dissolved in iron, the magnetic transformation-point, ordinarily 860° C., is lowered to an extent depending upon the amount dissolved. Most of these steels can be transformed by immersing them in liquid air. A bar of steel 3·8 cm. long and weighing 11·9 gr., made by Hadfield, and containing 0·59 per cent. carbon, 5·9 per cent. manganese, and 3·77 per cent. nickel was unable to attach itself to an electromagnet fed by a current of 5 amperes. After five minutes' immersion in liquid air the metal became magnetic, its lifting force being 1 kgr., and it retained its magnetic properties up to 650°. The effect of the cooling is to increase the permeability and the remanent magnetism, and also to reduce the density. Some specimens, such as Hadfield's 13 per cent. manganese steel and Guillaume's nickel-chromium steels, have their transformation-points lowered to such an extent that they do not become magnetic even at the temperature of liquid air. E. E. F.

1526. *Cast Iron and Steel.* **B. S. Summers.** (Elect. Engin. 23. pp. 654–658, 1899.)—This is an abstract of a paper read before the Iron and Steel Institute. It deals with irons containing silicon, sulphur, phosphorus, manganese, and carbon, and is illustrated with a number of B-H curves, but does not well admit of an abstract. E. C. R.

1527. *E.M.F. Produced in Flame by Magnetic Action.* **R. Blondlot.** (Comptes Rendus, 128. pp. 1497–1498, June 19, 1899.)—If the terminals of a capillary electrometer be connected to two platinum wires, and if the latter be introduced into the edges of the fan-shaped flame of a gas-burner so as to occupy symmetrical positions, no permanent deflection is obtained, but only a feeble oscillatory movement caused by the variations of temperature due to the flickering of the flame. If, however, the flame be placed between two plane pole-pieces of an electromagnet, with the plane of the flame itself parallel to the polar faces, then on exciting the magnet a deflection is obtained. This result may be very simply explained by noticing that the portion of the flame between the ends of the platinum wires is a conductor which is moving normally across the magnetic field, and in which there is therefore an E.M.F. induced by the motion. A. H.

1528. *Dielectro-Magnetic Media.* **V. Boccara** and **M. Pandolfi.** (N. Cimento, 9. pp. 254–259, 1899.)—The authors have studied what they call a "dielectro-magnetic medium" made of iron powder intimately mixed up with paraffin. The iron used was chemically pure, and was suspended in the liquid paraffin as an impalpable powder. After cooling, perfectly homogeneous masses of dielectric were obtained, as shown by the uniformity in the density of different parts. When the percentage by weight of the iron in the mixture exceeds 50 the latter becomes conducting, and it was therefore necessary to confine the measurements of the inductivity or dielectric constant to percentages below that. The method adopted was that of the induction balance, with improvements on Gordon's arrangement. The balance consists of five discs of zinc 4 mm. in thickness, with rounded edges, one of which is movable at right angles to its surface, while the others are held in position by three wires each. The second and fourth discs are connected to the quadrants of an electrometer, and the central one with the electrometer needle. The disc whose inductivity is to be determined is introduced between the first and second disc, and the first (zinc) disc is shifted until balance is obtained. The results obtained show that the inductivity increases more and more rapidly with the percentage of iron. E. E. F.

1529. *Magnetic Properties of the Elements.* **S. Meyer.** (Wied. Annalen, 68. 2. pp. 325–334, 1899.)—The author summarises the attempts that have been made to connect the magnetic properties of the elements with their atomic weights and the periodic law. Königsberger is the author of the most important compilation on the subject, but the author has made some measurements upon the elements themselves instead of solutions of their salts, since the latter introduce the unknown influence of the solvent. Needless to say, the results are very rough, some of them only qualitative in fact. Meyer's table of atomic magnetisms, in which the elements are arranged in the usual periods, show certain interesting peculiarities which distinctly indicate a dependence of permeability upon atomic weight. Thus the elements at the beginning and end of each horizontal series are invariably diamagnetic (Li, Na, K, Rb, Cs; Br, I, Bi), the paramagnetic elements all being grouped in the middle, with a tendency towards the beginning of the series. Sulphur and phosphorus, which are diamagnetic, are the only exceptions to this rule, unless they are taken as ending the second horizontal row. Chlorine really ends it, but its magnetic qualities are quite unknown. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1530. *Expansion of Metallic Alloys.* **H. Le Chatelier.** (Comptes Rendus, 128. pp. 1444–1447, June 12, 1899.)—Maxima of curves of fusibility do not correspond to exact equivalent proportions. Coincident with these maxima are maxima of expansion, which are much higher than those corresponding to the pure metals or to the definite equivalent alloy. The most expansive alloy can therefore not consist of a mixture of crystals of metal and alloy, and the inference is that we have in this case to do with a solid solution. Similar results ought to be obtained in regard to micrographic structure and electric resistivity. A. D.

1531. *Properties of Aluminium.* **A. Ditte.** (Annal. Chim. Phys. 17. pp. 145–173, June, 1899.) (See 1899, Abstracts Nos. 847 and 1064.)—An alloy of aluminium with about 3 per cent. of copper when heated to dull redness and then cooled in water becomes roughly crystalline and full of minute cracks, which accelerate the destructive action of solutions containing salt and acids. Aluminium cooking vessels may be subject to treatment of this kind. T. E.

1532. *Applications of Aluminium.* **H. Moissan.** (Comptes Rendus, 128. pp. 895–901, 1899.)—Referring to Ditte's experiments, the author lays stress on the great influence exerted by the purity of aluminium on its resistance to corrosion, and on the importance of excluding the possibility of electrolytic action due to the contact of some other metal with the aluminium. Reports from different officers of the French army are quoted speaking highly of the endurance of aluminium cooking utensils used for military purposes. Tinned or soldered vessels of iron suffer even more when heated to redness than those of aluminium. The author's personal experience of aluminium cooking utensils has been entirely favourable. T. E.

1533. *Atomic Weights of Oxygen and Hydrogen.* **A. Leduc.** (Comptes Rendus, 128. pp. 1158–1159, 1899.)—Synthesis of water gives the ratio 15·88 : 1·00. A density method gave 15·868 : 1·00; but this, when correction is made for the alteration in pressure when the two gases are mixed, becomes 15·878 : 1·000. A. D.

1534. *Vulcanised Indiarubber.* **H. L. Terry.** (Electrician, 43. pp. 160–162, 1899.)—The writer compiles a few scattered opinions as to the cause of the decay of vulcanised rubber, some of which agree with the facts. R. A.

1535. *Affinity of Organic Bases in Aniline (Aminolysis).* **H. Goldschmidt** and **R. M. Salcher.** (Zeitschr. Phys. Chem. 29. pp. 89–118, 1899.)—The partition of acids (HCl, HBr, HNO_3, and o-Nitrobenzoic acid) between aniline and various bases dissolved in the aniline is determined by the rate of conversion of diazoamidobenzol in amidoazobenzol, which is found to be proportional to the concentration of aniline salt. The results are roughly proportional (the factor varies from 6 to 20×10^8) to the coefficients of affinity in aqueous solution. The proportionality between reaction velocity and acid concentration excludes the idea of electrolytic dissociation being the determinating factor. B. B. T.

1536. *Amalgams of Alkali-Metals.* **E. Maey.** (Zeitschr. Phys. Chem. 29. pp. 119–138, 1899.)—The specific volumes of amalgams of sodium, potassium, and lithium are determined. The curves connecting these with composition are found to consist of a series of straight lines, the intersecting points of which are taken to indicate the following definite compounds:—

$NaHg_5$, $NaHg_2$, $NaHg$, Na_3Hg.
KHg_{11}, KHg_5, KHg_3, KHg_2, KHg.
$LiHg_5$, $LiHg_3$, $LiHg$, Li_3Hg.

B. B. T.

1537. *Equilibrium of a One-Component System.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 334-336, 1899.)—This is a continuation of the author's elucidation of Gibbs' thermo-dynamical studies, and will doubtless be very welcome. The stability-theorem due to Gibbs (Trans. Conn. Acad. 2. 390, 1873) is proved by the author in a concise and lucid manner. F. G. D.

1538. *Reaction Velocity.* **R. H. Bradbury.** (Frank. Instit. Journ. 147. pp. 463–474, June, and 148. pp. 65–73, July, 1899.)—A short account of the theory of reaction-velocity, in which the author gives the various types of reactions, the equations applicable to them, and well-known instances where these equations have been found to hold good. The short *résumé* given does not attempt to be exhaustive. F. G. D.

1539. *Dissociation of Nitrogen Peroxide.* **A. Pochettino.** (N. Cimento, 9. pp. 450–454, June, 1899.)—The ratio of the specific heat varies from 1·17 corresponding to N_2O_4, to 1·30, corresponding to NO_2. Slight divergences from the calculated ratio are attributable to temporary dissociations induced by the sound-waves used in ascertaining the value of the ratio. A. D.

1540. *Osmotic Pressure.* **A. Ponsot.** (Comptes Rendus, 128. pp. 1447–1448, June 12, 1899.)—With very dilute solutions of NaCl the value of *i* is between 1·76 and 1·81, not 2·00. A. D.

1541. *Osmotic Pressure and Osmotic Work.* **C. Dieterici.** (Zeitschr. Phys. Chem. 29. pp. 139–146, 1899.)—A reply to Noyes (Zeitschr. Phys. Chem. 28. pp. 220–224, 1899; see 1899, Abstract No. 1223), with some further considerations on the experimental realisation of a system to determine osmotic pressures directly. B. B. T.

1542. *Boiling-Points of Mixed Liquids.* **J. K. Haywood.** (Journ. Phys. Chem. 3. pp. 317–327, 1899.)—The curve of boiling-points for mixtures of alcohol, chloroform, and acetone with certain of the following, viz., water, benzene, carbon tetrachloride ether, methyl alcohol, and with each other are determined. The curves for acetone-water and acetone-chloroform have a wave form, the first being convex upwards at the acetone end, the latter showing a well-marked maximum at the chloroform end: all other curves are convex downwards: those for ethyl alcohol with benzene, carbon tetrachloride, and chloroform, and for chloroform with methyl alcohol, show a well-marked minimum. The addition of water to ethyl alcohol, or carbon tetrachloride, or methyl alcohol to acetone alters the boiling-point very little. B. B. T.

1543. *Cryoscopic Behaviour of Substances Analogous in Constitution to their Solvents.* **F. Garelli and F. Calzolari.** (Roma R. Accad. Lincei Atti, 8. pp. 579–590, 1899.)—Experiments on fusing points of solid solutions in a series of chemically analogous bodies. A. D.

1544. *Heat of Solution.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 29. pp. 159–161, 1899.)—Continuation of the controversy with Noyes (see 1899, Abstracts Nos. 149, 729, and 730). The author maintains that the *integral* (i.e., *integrated*) heat of solution employed by Noyes in the van't Hoff equation connecting temperature-variation of solubility with heat of solution is incorrect. Van Laar maintains that the *differential* heat of solution at saturation must be used. F. G. D.

1545. *Conductivity of Electrolytes.* **W. Foster, Jr.** (Phys. Rev. 8. pp. 257–281, 1899.)—Determinations are made of NH_4NO_3, $MgCl_2$, $MgSO_4$, $NaNH_4$, HPO_4, NaH_2PO_4, KH_2PO_4, H_3PO_4, NaOH, $H_2C_2O_4$, and citric acid in dilutions up to 10,000. The results agree well with those of Loomis on freezing-point depressions. B. B. T.

1546. *Theory of Lead Accumulators.* **F. Dolezalek.** (Zeitschr. Elektrochem. 5. pp. 533-539, 1899.)—The relation between the E.M.F. of a lead accumulator and the concentration (c molecules per litre) is represented by the simple formula $E=1{\cdot}895+0{\cdot}12\log c+0{\cdot}001c$, provided the acid is of not more than 2-normal strength. This equation is deduced theoretically by several independent methods and its accuracy is proved by a series of direct measurements. The E.M.F. of an accumulator filled with saturated lead sulphate solution is found to be 1·25 volts at 0°, whence it is shown, by an application of the above formula, that lead sulphate is hydrolytically dissociated to the extent of at least 15 per cent. Similarly, from measurements obtained with an accumulator charged with 0·1 normal alkali the electrolytic dissociation of water is calculated, the value arrived at ($0{\cdot}33\times10^{-7}$ mols. per litre) being in close agreement with Kohlrausch and Heydweiller's result ($0{\cdot}35\times10^{-7}$).

In the second part of the paper the influence of concentration of the acid on the potentials of the electrodes considered separately is discussed, and experiments are described in which these values were measured against a hydrogen and a mercury sulphate electrode in connection with the accumulator. The results obtained have some interest in connection with the phenomena of self-discharge, and it is calculated that with 50 per cent. acid the waste at the lead plate is five times, and at the peroxide plate three times, as great as with 5 per cent. acid. N. L.

1547. *Theory of Accumulators.* **E. Hoppe.** (Elekt. Runds. 16. pp. 15–16, 1898.)—An account of the actions which take place in secondary cells from the point of view of recent theories as to solution and the movements of the ions. J. J. S.

1548. *Electrolysis of Copper Sulphate Solutions.* **F. Foerster.** (Zeitschr. Elektrochem. 5. pp. 508–513, 1899.)—Some of the results obtained by the author in conjunction with O. Seidel (Zeit. Anorg. Chem. 14. 106, 1897) are described, and shown to be in full agreement with the observations of Hübl, whose work had previously been overlooked. As regards the physical properties of the electrolytically deposited metal, the brittle deposits obtained from neutral, or slightly basic, copper sulphate solutions are contaminated with cuprous oxide, whilst the dark, spongy deposit yielded by neutral and acid solutions with a high current density probably contains a compound of copper with hydrogen. The most coherent and uniformly crystalline deposits are obtained by electrolysing at a temperature of 35–40° with a kathode current-density of about 1 ampere per square decimetre. Under certain conditions a spongy deposit, containing cuprous oxide, is formed at the anode, and it is suggested in explanation that the cupric ions at the kathode are converted into cuprous ions, which are unstable above a certain concentration, especially in neutral solutions, and are transformed at the anode into cupric ions with the deposition of metallic copper and cuprous oxide. Attention is finally drawn to the marked effect of the presence of minute quantities of organic substances, such as guttapercha and gelatin, on the character of electrolytic copper. N. L.

1549. *Electrolysis of Solutions of Cane-Sugar.* **K. Ulsch.** (Zeitschr. Elektrochem. 5. pp. 539–541, 1899.)—Experiments were made on the electrolysis of cane-sugar in dilute acid and alkaline solutions between platinum electrodes. When sulphuric acid is used the oxidation is by no means complete, only 63 per cent. of the total possible amount of carbonic anhydride being formed after 22 hours at the ordinary temperature, followed by 1½ hour's electrolysis at 100° with a current of about 1 ampere. The addition of manganese sulphate to the acid solution greatly facilitates the oxidation, which is also more rapid and complete in alkaline solutions, barium hydroxide being especially convenient. The carbonic anhydride produced never exceeds, however, 98–99 per cent. of the theoretical amount, small quantities of some unknown organic substances being formed, which escape the action of the current but are readily oxidised by heating with potassium permanganate solution. N. L

1550. *Electrolytic Carbamine.* **J. Möller.** (Zeitschr. Elektrochem. 5. pp. 463–464, 1899.)—The author has found that this compound is obtained on electrolytic reduction of nitrobenzene in an alcoholic solution containing sodium hydrate, without the aid of a diaphragm. The quantities used in one of his experiments were: nitrobenzene, 25 grammes; sodium hydrate, 40 grammes; water, 50 grammes; alcohol, 350 cc. The resulting solution was electrolysed with an E.M.F. of 7 to 8 volts, and a current density of 9–10 amperes per sq. decimetre, at a temperature of 60°–70° C., for thirty-six hours. Platinum electrodes were used. Carbamine, aniline, and unaltered nitrobenzene were present in the final solution, but the author was unable to determine the exact yield of the first.

The remainder of the paper is devoted to a discussion of Löb's theory of electrolytic reduction as applied to the nitrobenzene series of compounds. Löb in his investigations had made use of a diaphragm, and the author gives details of further experiments made by himself in order to determine the value and effect of the diaphragm in these reduction processes. J. B. C. K.

1551. *Electrolytic Synthesis of Azo-Compounds.* **W. Löb.** (Zeitschr. Elektrochem. 5. pp. 456–462, 1899.)—After an enumeration of some of the difficulties attending the preparation of these organic bodies by purely chemical methods, the author describes the method of electrolytic reduction used in his experiments. The corresponding nitro-compounds are used as starting-points of the process. Platinum, mercury, or nickel are used as kathode materials. When mercury is used, a large glass beaker is used as reduction vessel; while, when the other metals are used, a clay cylinder is preferable. A strong solution of sodium hydrate is in each case used for the anode electrolyte. The electrolyte in the kathode compartment of the cells is an alcoholic alkaline solution of the nitro-compound.

Precautions are necessary to avoid chemical action on mixing the kathode solutions, in the case of the compound derivatives.

Full details of the application of this general method to the preparation of the following are then given:—

I. *Simple Azo-Compounds.*

o-Azo-toluene. m-Diamido-azo-benzene.
p-Diamido-azo-benzene-disulphonic acid.
Tetra-methyl-diamido-azo-benzene.
p-Azo-toluene-disulphonic acid.

II. *Mixed Azo-Compounds.*

o-touluene-azo-benzene.	Azo-toluene-benzoic acid.
m-Sulph-azo-benzoic acid.	Amido-azo-benzoic acid.
Amido-azo-sulph-benzoic acid.	Dimethyl-amido-benzene-azo-benzoic acid.

J. B. C. K.

1552. *Organic Substitution Products.* **E. Votoček** and **E. Zenišek.** (Zeitschr. Elektrochem. 5. pp. 485–486, 1899.)—The authors have worked out a new electrolytic method for bringing about the substitution of halogens for the amido or diazo groups in benzene compounds. Full details of the application of this method to the preparation of chloro-benzene; bromo-benzene; o-toluene chloride; p-toluene chloride; and napthalene chloride are given.

To prepare chloro-benzene, a solution of 50 grms. aniline in 120 grms. 30 per cent. hydrochloric acid is treated with 38·5 grms. sodium nitrate in order to obtain the diazo-derivative; 170 grms. copper sulphate are then added, and the resulting solution is electrolysed with an E.M.F. of 12 volts and a current density of 1·6 amperes per sq. decimeter. A copper spiral is used as anode, and a copper foil cylinder as kathode. The electrolyte must be kept at a low temperature by means of ice during the electrolysis. The evolution of oxygen ceases at the end of two hours. 24·9 grms. chloro-benzene (equal to a current effciency of 42 per cent.) were obtained by the authors under these conditions of work.

The other halogen products were obtained in a similar manner, potassium bromide and sulphuric acid being substituted for hydrochloric acid in the case of the bromine derivative.

J. B. C. K.

1553. *Impurities in Aluminium.* **A. Minet.** (Comptes Rendus, 128. pp. 1163–1167, 1899.)—Progress in the electro-metallurgy of aluminium has been accompanied by a notable improvement in the quality of the commercial metal produced, as shown by the following table:—

Composition of the Metal.	In 1890.	In 1893.	In 1897.
	Per cent.	Per cent.	Per cent.
Silicon	0·90	0·25	0·02
Iron	0·40	0·40	0·12
Aluminium......	98·70	99·35	99·86

Three types of Minet furnace are briefly described. W. G. M.

1554. *Borchers' Carbide Furnace.* (Electrician, 43. pp. 111–112, 1899.)—The disadvantages of the usual type of furnace when used for carbide production are summarised as follows: 1. Loss of carbon dust with waste gases. 2. Loss of carbide by exposure to air in heated state. 3. Loss of heat in fused carbide.

The improved Borchers' furnace consists of a smelting chamber with thin walls enclosed in a water-jacket. The finished block of carbide is left for several hours in the furnace, and the heat which it gives out is utilised for steam generation. By working a series of such furnaces at intervals of two hours or less, a constant supply of heat for steam generation can be obtained.

The carbon required for the formation of carbide is supplied by the electrodes; and the lime is used in the form of lumps, not in a fine powder. When the necessary heat has been attained within the furnace, the lime around the electrodes unites with these to form carbide, and this latter flows away in the fused state. The size of the furnace and the charge of lime are so adjusted that the sides of the smelting chamber are always protected by a layer of unused lime from the action of the intense heat at the centre. The system can be used with either arc or resistance furnaces. Borchers claims for these furnaces that by their use one-fourth of the power hitherto used in carbide production can be saved. J. B. C. K.

1555. *Carbon Electrodes.* **J. Zellner.** (Zeitschr. Elektrochem. 5. pp. 450–456, 1899.)—The results of an extended series of observations are summarised by the author as follows:—

1. The durability of a carbon electrode depends not upon its sp. gr., but upon its structure—that is, upon the resistance which its molecules offer to disintegration by the gases evolved during electrolysis.

Low "porosity" (a term explained in the original paper) is, in general, favourable to durability, but is not an absolute criterion of this quality.

2. Neutral or alkaline solutions are favourable to the life of the electrode. Chlorine alone is not very dangerous, but oxygen liberated in acid solutions is especially harmful.

3. The consumption of carbon within recognised limits depends upon the E.M.F. and intensity of the current. It does not depend upon the form or active surface of the electrode. In other words, carbon consumption and current density are proportional one to the other, when the same electrolyte is used.

4. The life of the electrode is promoted by high electrical conductivity of the electrolyte, and by a low E.M.F. and low temperature of the cell.

5. The life of the electrode is promoted by maintenance of a correct relationship between the electrical resistance of the electrodes and of the electrolyte. J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1556. *Bichromate Cell.* **W. Weiler.** (Elekt. Runds. 16. pp. 41–42, 1898.)—A description of a form of bichromate cell in which the positive plate consists of a disc of carbon placed at the bottom of the cylindrical glass vessel containing the exciting liquid (12 parts bichromate of potash to 25 parts of concentrated sulphuric acid and 100 parts of water), the negative plate being a star-shaped block of cast zinc fixed at the centre to the lid of the cell. The carbon has joined to it a carbon rod passing to the top of the vessel with a metal terminal. The arrangement may conveniently be fitted up as a gravity cell, the vessel being partly filled up with a solution of common salt and a mixture of one part of bichromate of potash crystals and two parts of potassium bisulphate crystals allowed to fall in through a tube passing to the bottom. J. J. S.

1557. *Automatic Pneumatic Switch for Accumulators.* (Elektrotechn. Ztschr. 20. pp. 317–318, 1899.)—This device, due to E. Petersen, of Copenhagen, depends for its action on the fact that as a secondary cell is nearing the completion of its charge it gives off steadily increasing quantities of hydrogen and oxygen. The controlling cell of the battery is provided with an air-tight hood in which the gases are collected. A **U**-tube containing mercury communicates with the hood, and as the pressure of the gas increases the mercury is slowly driven up into the open limb of the tube. The mercury forms part of the main circuit, which it closes by means of two platinum contacts sealed into the tube. At a certain point the descending column of mercury leaves the platinum contact and breaks the charging circuit. Hitherto the arrangement has only been tried in the laboratory, with, it is said, satisfactory results. A. H.

1558. *New Rheostat Switch.* (Électricien, 17. pp. 225–226, 1899.)—This is a description of a switch which enables the various constituent parts of a resistance to be placed either in series or in parallel, thus admitting of a more gradual change of the total resistance in a circuit. W. G. R.

1559. *Safe and Accurate Fuses.* **J. Sachs.** (Elect. World and Engineer 33. pp. 781–782, June 3, 1899.)—This article contains a description of the Noark fuse. The exterior of the fuse simply shows a neat fibre tube, at each end of which is a brass ferrule; these ferrules form the contact terminals, or separate contacts of the standard hook type are attached. Inside the casing is a special alloy fuse wire entirely encased in a surrounding material. There is no air in contact with the wire throughout its entire length. The surrounding material and its arrangement about the wire play a most important part. In operation the rupturing of the wire of the fuse simply results in the combination between the metal of the wire and the surrounding material, resulting in the formation of a stratum of insulating material between the terminals. W. G. R.

1560. *Reconstructed Granite as an Insulator.* (Electrician, 43. p. 183, June 2, 1899.)—Maine granite is crushed, moulded into form, and fused at 3,000° F. It resists all but hydrofluoric acid, crushes at 14,560 lb. per square inch, and gives a tensile strength of 480 lb. per square inch; 56,600 volts were required to pierce ¼ inch of this material in the shape of cup insulators. M. O'G.

1561. *Maximum Demand Meter.* **E. S. Halsey.** (Elect. World and Engineer 33. pp. 628–629, 1899.)—The author describes an attachment to a Thomson integrating wattmeter to indicate maximum watts. The upper or motor part of the meter carrying an indicator or pointer is flexibly coupled to the lower portion carrying the retarding copper disc, which disc carries a kilowatt scale; a pawl and ratchet prevent relaxation of the spring coupling, and a viscous dressing at the junction of the upper and lower shaft acts as a retarding agent and permits sluggish action. The armature torque is always proportional to the load passing through the meter, regardless of speed of rotation, even if the drag disc were stuck so that it could not move; the drag is always equal to the torque whether the meter is fast or slow, or the magnets are weak or strong; the two parts are coupled by a spring, the amount of tension of which is always equal to the strain supplied. E. C. R.

1562. *Differential Rate Meter.* **L. C. Reed.** (Elect. World and Engineer 33. pp. 676–678, 1899.)—A disc divided by radial lines into three-hour divisions is driven by a clock mounted on the top of the meter case. The shaft, which usually carries the index pointer for the initial or primary dial of the integrating train of the meter, is extended from the front of the dial-plate a sufficient distance to carry a disc-shaped cam, the cam portion being in the form of a peripheral notch, having a rounded edge. In front of the cam disc is arranged a bracket; this supports a small oscillating spindle, to which is connected an oscillating lever bearing a pencil or stylus in such a manner that the lever bearing on the disc cam keeps the pencil from touching the chart disc;

when, however, the lever falls into the notch in the cam, the pencil makes a mark on the dial. The working of the device is obvious, as it will be seen that a fixed unit, equal to one revolution of the initial counting dial, is recorded on the chart at intervals, the distance between the dots being the time consumed in recording this unit. E. C. R.

1563. *Chamberlain and Hookham's Two-rate Meter.* (Electrician, 43. pp. 440–441, July 21, 1899.)—This meter automatically changes to a higher rate when the rate of consumption is increased to any prearranged figure. M. O'G.

1564. *Carbons.* (Amer. Electn. 11. pp. 295–297, June, 1899.)—The National Carbon Company's works at Cleveland, U.S.A., which are said to be the most perfect of their kind, are here described. Electric light carbons of every variety form their staple product, together with every form of electrolytic and battery carbon. The raw material employed is the coke from the oil refineries, being the solid material left in the stills after the volatile oils have been distilled off. The process consists in grinding the coke and mixing it with binding material of special composition. The pencils are formed in two ways, either by placing a weighted quantity of material in moulds with grooves and pressing two of such moulds together under a press, thus forming a number of pencils connected with a thin web, or by squeezing the material through dies from a hydraulic press. The pencils, after drying, are cleaned up and made of uniform length, and then baked for eight or nine days in gas-fired furnaces out of contact with the fire gases or air. Other shapes for electrolysis, &c., are moulded in presses and baked in the same way. The finished articles are classified, great care being taken to get the pencils quite straight. When copper plating is required, it is done in the ordinary way for battery plates, &c., but a special machine has been erected, with which pencils can be automatically plated. They are fed into the apparatus and gripped on to a conveyor so that the projecting ends can be immersed in the copper bath. Illustrations of this machine and of the furnaces, &c., are given. J. L. F. V.

1565. *Installation Estimates.* (Elect. Rev. 45. pp. 126–127, 165–167, and 220–222, 1899.)—Gives methods of arriving at first cost of private and general electric lighting installations, and also some particulars of the working expenses and maintenance of the same. EDITOR.

1566. *Wiring Calculations.* **A. Vallée.** (Électricien, 17. pp. 273–274, 291–292, and 311–313, 1899.)—The chief point considered in these articles is the calculation of the most economical method of wiring consistent with a fixed maximum of heating of the conductors. Methods of approximate calculation are given in specific cases. W. G. R.

1567. *Steering Torpedoes by Hertz Waves.* (Electrician, 43. pp. 112–114, 1899.)—The steering mechanism is controlled by a so-called "selector switch," which allows an electric current to pass either to one or the other of two solenoids which operate the helm. The selector switch works in conjunction with a coherer, and the arrangement is such that, when the coherer is under the influence of Hertz waves, the helm is first put over automatically to "port"; when the Hertz waves cease, the helm automatically rights itself; and when the Hertz waves are once more sent, the helm is put over automatically to "starboard"; or, if it is desired to go to "port" again, two wave-impulses are sent in quick succession. R. A.

1568. *Electric Heating in a Hospice.* (Elect. World and Engineer 34. pp. 138–140, July 22, 1899.)—The new Carmelite hospice on the Canadian side of the Niagara Falls is provided with complete electric heating and cooking apparatus. Three-phase current at 2,200 volts is carried on No. 3 bare copper wire from a supply station distant two miles. It is tranformed to 110 volts by two 30-kw. and one 25-kw. transformers at the hospice. A switchboard with double-throw switches controls two phases of the current, and the third phase is controlled by an adjacent switchboard, and is used for cooking, lights, &c. Power amounting to 100 H.P. is taken by contract, 25 H.P. of which are used for lighting (200–16 cps.), cooking, and heating water, while the remaining 75 H.P. is applied to heating the lower floor of the building, containing eleven bedrooms, dining-room, reception-rooms, and corridor. Each bedroom is 15 × 12 × 10 feet high, and contains one 4 H.P. heater with two heats. The corridor is 120 × 15 × 10 feet high, and contains nine 4 H.P. heaters. The kitchen contains one electric range and three ovens. The range has 6 square feet of heating surface, each square foot consuming 15 amperes and having a two-heat switch. The small ovens take 23 amperes at 110 volts, and the large one 50 amperes. Four 25-lb. roasts can be handled at one time. The pantry has three 5-gallon electric urns for tea, coffee, and hot water. Close to the switchboard are two electrically operated boilers, one holding 400 gallons, the other 150 gallons. The former, which supplies the laundry and baths, takes 120 amperes and has three heats. The latter supplies the kitchen, and takes 125 amperes, being principally used for quick boiling. On the opening day the kitchen electrically cooked dinner for 250 people. The big boiler will heat water from 60° F. to 212° F. in six hours. The small ovens bake bread in eighteen minutes. The large oven is furnished with a thermometer. The current for water-heating, cooking, and lights costs $25 per H.P., or $625 a year, while the 75 H.P. used in warming the building is secured at about one-fifth of this price per H.P. The plant as a whole requires little care for its operation, and gives great satisfaction. E. H. C.-H.

1569. *Electric Drawbridge Contact.* **E. T. Birdsall.** (Elect. World and Engineer 34. p. 116, July 22, 1899.)—Illustrates and describes the contact device on the drawbridge over the Harlem River, N.Y., one of the largest draws in the world. It is lighted by enclosed arcs, the current for which is conveyed to the approaches by armoured rubber cables connected to the contact device. Flexible cable was impossible, as the draw revolves often in one direction. The device consists of a marble block, in which are turned two cavities, one a circular central opening and the other a circular groove concentric with the central cup. In the centre opening is placed a copper disc and connecting lug; in the annular recess is placed a copper ring, to which a lug is attached. This ring and centre disc with their lugs are bedded in "Edison compound" in the marble block. The terminals attached to the lugs are protected by a second block of marble, having proper recesses, cemented to the upper block with similar compound. The upper or movable part consists of a copper rod carrying a disc on the lower end, surrounded by an insulated copper tube carrying a ring and a thin brass dust shield. The upper ring and disc are adjusted to within one-sixteenth inch of the lower ones and enough mercury poured in to fill the cups nearly to the top of the upper ring. The lower part of the device is not fastened to the bridge structure, but is free to move to accommodate itself to any eccentricity of the draw, being connected to the junction boxes by flexible cables. The upper part is adjustably secured to the draw by means of "Barn" type of trolley hangers. E. H. C.-H.

1570. *Electricity on American Vessels.* **J. McGhie.** (Elect. Engin. 23. pp. 433–436, 464–466, and 532–534, 1899.)—This is an illustrated description of the electrical plant on board certain ships, and it cannot well be abstracted. The coal conveyors of *La Grande Duchesse* and the electric cranes on the *Bremen* are described at some length; the latter are operated by a controller, so arranged that the movements of the single handle correspond with the movements of the load in any desired direction. A. H. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

1571. *Armature Reaction.* **A. Potier.** (Écl. Électr. 19. pp. 241–246, 1899.)—The author criticises a paper written on the subject by Picou, and states that the effect of armature reaction in a continuous current machine depends to a great extent upon the teeth in the case of slotted armatures. He proceeds to calculate the amount of armature reaction in specific cases. He also calculates the effect of auxiliary poles. W. G. R.

1572. *Hysteresis Loss in Armature Core-Discs.* **J. Epstein.** (Elektrotechn. Ztschr. 20. p. 326, 1899.)—The author draws attention to the contradictory results obtained by different experimenters with regard to the effect of frequency on the hysteretic loss per cycle. Thus, Warburg, König, Tanakadaté and Weihe (see Phys. Soc. Abstract, No. 619, 1897) found this loss to be less by 20 to 30 per cent. with alternating currents than with a slowly performed cycle. Hopkinson found practically no difference. Maurain (see 1899, Abstract No. 129) found the hysteretic loss to be independent of the frequency for wires less than 0·5 mm. in dia., and to decrease with increase of frequency for thicker wires. Wien (see 1899, Abstract No. 322) concluded from the results of his experiments that the loss with alternate currents exceeded that determined statically. Lastly, Niethammer (see 1899, Abstract No. 835) found that the hysteretic constant was greater for alternate currents. The author suggests that these conflicting results may in part be due to the simple fact that the behaviour of iron in this respect varies from one specimen to another. He emphasises the necessity of testing core discs under the usual working conditions, and refers to a testing apparatus used by Lahmeyer & Co., which is arranged for testing quantities of 30 kgs. at a time. Tests carried out with small test-pieces are unsatisfactory, as the quality of the iron may vary greatly, not only in different plates belonging to the same lot, but in different parts of the same plate. A. H.

1573. *Mechanical Stresses in Slotted Armatures.* **P. M. Heldt.** (Elect. World and Engineer 33. pp. 699–700, 1899.)—In a slotted armature, the ratio of the actual force on a conductor to the mean torque per conductor is the same as the ratio of the magnetic induction in the slot to the induction in the air-gap. Let l be length of core, w mean width of tooth,

d depth of slot, B induction in tooth, a length of air-gap. Then reluctance of tooth is $\frac{d}{wl\mu}$, and reluctance of that part of air-gap through which this induction passes is $\frac{a}{1{\cdot}2wl}$. The coefficient $\frac{1}{1{\cdot}2}$ represents allowance for increased width of tooth at its face and fringing of magnetic lines. The magnetic flux is wlB, and the difference of magnetic potential between polar face and bottom of tooth is $B\left(\frac{d}{\mu}+\frac{a}{1{\cdot}2}\right)$. The magnetic reluctance of a prism of unit area in the slot is $d+a$, the induction in the slot is $\left(\frac{\frac{d}{\mu}+\frac{a}{1{\cdot}2}}{d+a}\right)B$. Let $v=\frac{\frac{d}{\mu}+\frac{a}{1{\cdot}2}}{d+a}$, that is the ratio of the induction in the slot to the induction in the teeth, then if w_2 is the width of the slot the ratio of induction in the slot to induction in the gap is $\frac{(w+w_2)v}{w+w_2v}$, that is the ratio of the actual force on a conductor to the mean torque per conductor. In a slotted armature Mordey found by experiment that this ratio was 0·1, and in a tunnel armature Houston and Kennelly found it 0·014.

R. B. R.

1574. *Heating of Commutators.* **H. W. W. Dix.** (Elect. Rev. 44. p. 848, 1899.)—It is desirable to make commutators and brushes of dynamos as small as possible, consistent with good working. The author suggests a method of readily determining the most economical size of both to suit any given set of conditions.

The total watts lost by commutation is given by—

$$W=\frac{2k_1\,C^2}{A}+\frac{pA\,\mu V}{k_2} \qquad (1)$$

where k_1 = contact resistance in ohms per square inch
= 0·003 ohm for copper brushes
= 0·03 ohm for carbon brushes
p = brush pressure on commutator in pounds per square inch = 1·25
μ = coefficient of friction = 0·3
A = total area of the positive brushes in square inches
V = peripheral speed of commutator in feet per minute
C = amperes carried by commutator
k_2 = constant = 22.

Differentiating equation (1) with respect to A and equating, the minimum value of W is given when—

$$A=C\sqrt{\frac{2k_1\,k_2}{V\mu p}}$$

The value thus obtained is inconveniently large and as in this neighbourhood a diminution of A produces but small increase in W, the author takes half this value as the most suitable one for practical purposes, and obtains—

$$A=\frac{C}{2}\sqrt{\frac{2k_1 k_2}{V\mu p}}$$

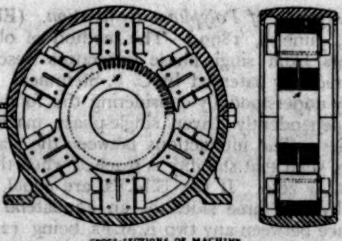
$$=\frac{C\times 0{\cdot}297}{\sqrt{V}} \text{ for copper brushes.}$$

$$=\frac{C\times 0{\cdot}936}{\sqrt{V}} \text{ for carbon brushes.}$$

The values of the constants are taken from Parshall and Hobart's articles in *Engineering*. W. G. R.

1575. *New System of Polyphase Generation*. (Electrician, 43. pp. 236–239, June 9, 1899.)—The method of obtaining polyphase currents from single-phase generators described in the paper is one recently patented by C. P. Steinmetz. Its principle will be readily understood by considering the following example. Let three independently driven single-phase machines be connected in series. The interactions between the machines are, as is well known, such that stability is reached when the sum of the three E.M.Fs. is zero. If the E.M.Fs. are equal, they may be represented by the three sides of an equilateral triangle, the phase-difference between any two E.M.Fs. being 120°. If therefore three conductors be taken from the junctions of the three alternators, three-phase currents may be obtained from these conductors. At the same time, each machine may be supplying its own single-phase load. Similarly, two-phase currents may be obtained from two single-phase machines by connecting them in series with one another and with an induction motor; the latter supplies the E.M.F. which closes the triangle of E.M.Fs., and by suitably adjusting the conditions under which the motor runs any required phase difference between the two single-phase machines may be obtained. The same arrangement may be extended to any number of single-phase machines coupled in series. When the number of machines exceeds three, the polygon of E.M.Fs. ceases to be rigid, *i.e.*, the phase-differences between the various machines cease to be definite; hence it becomes necessary, in order to secure rigidity of the E.M.F. polygon, to break it up into triangles, by introducing auxiliary E.M.Fs. (supplied by an induction motor), represented by the diagonals of the polygon. The system is very flexible, and allows of the supply of polyphase currents to a section of the mains from a power station equipped only with single-phase machines, this requiring no change whatever in the machines themselves, but merely a slight modification in the switching arrangements and inter-connections. A. H.

1576. *New Generator with Minimum Field Distortion.* **R. Lundell.** (Elect. World and Engineer 33. pp. 518–521, 1899.)—This is a description of a new constant potential dynamo made by the Sprague Electric Company to the following specification: The machine is to be of simple design and of smallest possible dimensions and weight per kilowatt output. It must not heat more than 75° F. above the surrounding air after a continuous ten-hour run at full load. It must be non-sparking at the brushes between no load and 50 per cent. overload, and it must not show injurious sparking at short time overloads of 100 per cent. without change of position of the brushes. The machine must respond quickly to changes of load, and the characteristic curve of potentials for various current outputs should approximate as nearly as possible to a straight line. It must necessarily be efficient, durable, and reliable in all details of construction.



CROSS-SECTIONS OF MACHINE

The chief features of this machine are the precautions taken to ensure cool and sparkless running.

The accompanying diagrams show the nature of the devices used. Each field-pole is divided into two parts by a ventilating slot and the two halves of the pole differ as regards the polar face, one half being elongated so as to have a much larger polar face than the other half, the result being that the half with the larger polar face becomes saturated before the other half. On increasing the current the part with the larger polar face has its magnetism increased but slightly compared with the increase in the other part. The result is that the distortion of the field is considerably diminished and can be so arranged that the point of commutation is not materially altered. W. G. R.

1577. *Alternate Current Motors.* **C. F. Guilbert.** (Écl. Électr. 19. pp. 161–169, and 208–213, 1899.)—Descriptions of recent patents referring to several types of alternate current motors. EDITOR.

1578. *Headland's Motor for Electric Vehicles.* (Automotor Journal, 3. pp. 405–406, 1899.)—The chief feature of this motor is that both the armature and the field-magnets revolve at the same speed but in opposite directions; both also act as drivers. This is effected by having two motors on the same axis, the armature of one being rigidly coupled to the field of the other. By use of a hollow shaft the armatures rotate in opposite directions. By the medium of a pinion and wheel for one armature shaft, two driving wheels are obtained rotating in the same direction. Balance of the rotating parts is claimed as well as the absence of need for differential gear. E. H. C.-H.

1579. *Measurement of Slip in Induction Motors.* **M. v. Hoor.** (Zeitschr. Elektrotechn. Wien, 17. pp. 211–213, 1899. Extract from the Königl. ungar, Akademie der Wissenschaften, March 13, 1899.) — The slip of an induction motor is generally a very small percentage of its speed (being only from 2 to 2½ per cent. in the case of 40 to 50 H.P. motors when fully loaded), so that any attempt to determine the slip by direct observation of the speeds of generator and motor must result in failure. The author describes a number of reliable methods, all of which have been tested by him in practice with satisfactory results. These methods fall under two heads, the first comprising stroboscopic methods, and the second those in which the frequency of the induced currents is determined. In the stroboscopic method, the rotor shaft carries a disc with alternate black and white sectors, the disc being illuminated by an alternate-current arc fed by the generator. The apparent rotation of the disc is a direct measure of the slip. A modification of this method, in which the arc lamp is done away with, and a polariscope is used, is also described. These methods are satisfactory so long as the slip is very small; beyond a certain limit the outlines of the sectors get blurred, and the eye is unable to follow the rapid rotation. Dealing next with methods depending on the determination of the frequency of the currents in the induced system, the author recommends the following method as being the most serviceable: A search coil some 6 or 7 cm. in dia., wound with 300 to 400 turns of 0·2 mm. wire, is connected to a telephone receiver. Round this coil are wound one or more turns of the cable connecting the induced system with the starting resistance. The ear is able to follow much higher frequencies than the eye, and this method is available over the entire range, which is important in practice. When the slip is small, a D'Arsonval galvanometer may replace the telephone.

The following crude arrangement may also be used in the case of large motors (80 to 100 H.P.): Instead of the ordinary short connecting cables between the induced system and its starting resistance, somewhat longer cables are used, two of them being freely suspended close to each other; the current-impulses along the cables set them vibrating synchronously with, and thus afford a means of determining the frequency of, the induced currents. Lastly, in the case of very large motors the slip may occasionally be determined from certain sounds emitted by the motor of a frequency equal to that of the slip. A. H.

1580. *Effect of Wave-Form on Transformer Losses.* **L. Duncan, F. B. Keidel, W. L. Hodges,** and **E. Frank.** (Elect. Rev. N.Y. 34. pp. 264–265, 1899.)—Current curves of various shapes are obtained by the authors by using two separately excited machines attached to the same shaft and imposing a third harmonic upon a fundamental wave. The form of the wave is obtained by plotting the instantaneous values of the voltage. The transformer used is one of the Westinghouse pattern designed for 133⅓ cycles per second. It is found that the losses are least for peaky voltage curves and greatest for flat curves. W. G. R.

1581. *Transformer Problems.* **C. Heinke.** (Elektrotechn. Ztschr. 20. pp. 175–178, 191–192, and 205–207, 1899.)—An elaborate exposition and critical discussion of the various methods of attacking problems in connection with the alternate-current transformer. A. H.

1582. *Rotary Converters.* **C. Pio.** (Elettricità. Milan. 18. pp. 117–120, 1899.)—This paper treats of the use of rotary converters as tramway generators, and describes some installations where they are employed at the end of a high-tension transmission line. After some discussion of their properties, the author mentions their liability to "hunt" when run in parallel. The General Electric Company, after numerous experiments, succeeded in avoiding this by bridging over the gap between two pole-pieces by a copper plate; the Foucault currents, induced in this, damp the oscillations of the field. The copper plates become hot and occasion a loss of power of about 1·5 per cent. The device is due to a suggestion made by C. P. Steinmetz.

G. H. Ba.

1583. *Practical Applications of Leblanc Rectifiers.* **E. Sartiaux** and **Aliamet.** (Soc. Int. Élect. Bull. 16. pp. 263–287, June, 1899.)—The paper contains an illustrated description of a number of lighting and power plants in which Leblanc rectifiers are made use of. Neither the theory nor the details of construction of the rectifiers themselves are given. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1584. *Polyphase Distribution.* **G. Stern.** (Zeitschr. Elektrotechn. Wien, 17. pp. 114–117, 1899. Extract from Report read before the Internationale Elektricitätsgesellschaft, February 8, 1899.)—A description of the arrangement adopted for the supply of two-phase currents from a central station which has hitherto been furnished with single-phase generators only. A. H.

1585. *Condensers in Alternate Current Power Transmission.* **L. Lombardi.** (N. Cimento, 9. pp. 354–381, 1899.)—The paper is divided into two parts: the first is theoretical, and gives formulæ for the variation of potential in circuits containing capacity, self-induction, and resistance; the second gives the results of measurements, made by the author, of the properties of different dielectrics.

In the first part, besides the usual cases, the author considers those where the dielectric possesses conductivity and hysteresis, where the self-induction medium is iron, where the insulating medium of the circuit possesses a certain conductivity, and finally, the practical case of a transmission line with transformers.

In the second part figures are given of—

1. Disruptive potentials at different distances through different dielectrics in air and in linseed oil.
2. Specific inductive capacities of different dielectrics.
3. Their "figures of merit," *i.e.*, the product of the S.I.C. and the ratio of the disruptive potential of the dielectric to that of air at the same distance.
4. The insulation resistances, and rapidity of polarisation of different condensers.
5. The energy absorbed by different dielectrics.

The author sums up as follows: The characteristic of a dielectric with regard to its practical use in a condenser are:—

i. Its insulation resistance per unit of S.I.C.

ii. Its absorption of energy from leakage and hysteresis (expressed by the author as the sine of the angle of lag which would produce the total absorption).

iii. The rapidity of polarisation (measured by the ratio of the apparent capacities measured by continuous and alternate currents).

iv. The maximum capacity it can present per unit of volume for a given potential difference (measured by the product of its disruptive potential compared with that in air and the dielectric constant).

The proportionate values of these four characteristics as measured by the author are:—

Dielectric.	*i.*	*ii.*	*iii.*	*iv.*
Mica …………………	7,000	0·000	1·007	42
Ebonite ……………	700	0·009	1·021	35
Paraffin wax…………	3,000	0·008	1·021	24
Guttapercha…………	400	0·042	1·050	28
Petroleum …………	20	0·014	1·7	7
Window glass ………	2	0·070	2·3	29

Taking the cost into consideration, the author concludes that the most suitable dielectric is paraffin wax, thoroughly free from air-bubbles. G. H. Ba.

1586. *Kootenay-Rossland Power Transmission.* **G. P. Low.** (Journal of Electricity, 7. pp. 69–76, and 85–92, 1899.)—The generating station of this plant has a capacity of 3,000 kw. and delivers three-phase current at 1,100 volts, which is transformed up to 20,000 volts for transmission. Air blast transformers are used and have proved very satisfactory, the arrangements for cleaning the transformers and air-ducts being well thought out. The two pole lines, each 31 miles long, which are fully described in the paper, present many points of interest. On one line both upper and lower cross arms on each pole are roofed, as a protection from the wet snow of the district. Another feature is a clear span of 1,500 feet across the Columbia River, the wires bearing their own weight unsupported by cables. The power is utilised almost entirely in mining and milling works, one mine alone having a 300 H.P. electric hoist driven by an induction motor, a 300 kw. synchronous motor driving a compressor, and many small induction motors for fans, conveyers, &c. The author gives full details of the regulation of the electric hoist which is working very successfully. M. G. W.

1587. *Water-Power in Italy.* **E. Bignami.** (Eng. Mag. 17. pp. 778–789, August, 1899.)—This paper contains tabulated statistics as to the water-power plants installed in Italy during the last ten years, but deals more particularly with the resources not yet developed and the best means of utilising them. The author gives a clear *résumé* of the state regulations as to water grants for power and irrigation purposes. M. G. W.

1588. *Boston Electric Light Company's Station.* (Elect. World and Engineer. 33. pp. 693–698, 1899.)—This new station contains generating plant of 9,400 H.P.

One of the most interesting features is the coal equipment. This includes a movable crane capable of raising 100 tons an hour, driven by a 500 volt motor on the Ward Leonard system, the generator being in the power house and the field rheostat in the crane tower; an electrically driven crusher; and a conveyer of 742 buckets driven by a 15 H.P. motor, which transfers the coal from the pier to the coal pockets. The storage capacity of the latter is 9,000 tons.

Four pairs of Babcock-Willcox boilers are installed, each pair supplying a 2,350 H.P. engine of vertical marine type. The engines are cross compounded and run at 120 revs. per minute; the governors are fitted with special speed-controlling device, which can be set by hand to control the speed through a considerable range for the purpose of synchronising or varying the distribution of load. The dynamos are general electric 60 cycle machines, rated at 1,500 kw. and guaranteed to carry 30 per cent. of overload for any length of time. The revolving fields are 16 feet diameter with 60 outwardly projecting poles, the field winding consisting of edge-wire strip. The external stationary armatures have six slots per pole with three-phase windings generating 2,250 volts.

The switchboard arrangements are very complicated owing to the number of motor generators in use, aluminium 'bus bars, 2 inches by 5 inches in cross section, are used for the three-phase currents.

The article is fully illustrated and contains a detailed account of a very completely equipped station. M. G. W.

1589. *Vienna Five-Wire Systems.* **J. Kolbe.** (Zeitschr. Elektrotechn. Wien, 17. pp. 4–9 and 17–23, 1899; also Zeitschr. des Œst. Ing.-und. Architekt. Ver., 1895.)—A description of two central stations in Vienna working on the five-wire system. A. H.

1590. *Generating Plant and Machinery in the Ivin's Building, N.Y.* (Elect. World and Engineer. 34. pp. 5–8, July 1, 1899.) —Each of the nearly 1,000 offices in this, the largest office building in the world, is electrically lighted, steam heated, supplied with hot and cold water, connected by telephone with an information bureau at the entrance, and has a messenger call-box. In all 7,500 incandescent lamps are used; dynamos having a total capacity of 575 kw., two boosters, a 500 kw.-hour battery plant, 900 H.P. battery of boilers, 1,000 H.P. in engines, 23 electric motors, and 15 elevators of all sizes (see 1899, Abstract No.

1424). To prevent accumulation of condensed steam in the dead-end of the main steam-pipe, a 3-inch pipe is tapped in and used for the pump supply. The drips from the high pressure steam-pipes are carefully collected and used, and the exhaust steam after passing through a grease extractor is returned to the house service lines and the feed-heater. The battery of 58 chloride cells giving 350 amperes for 10 hours, is provided with a ½-H.P. motor and air-compressor (8 lb. per square inch) for blowing air into the cells to equalise the density. The battery is charged by a booster with shunt and series windings so arranged that at heavy loads the battery discharges. Current for power is taken off inside the compound winding of the dynamos.

E. H. C.-H.

1591. *Dudley and Stourbridge Tramways.* (Elect. Rev. 45. pp. 149–153, July 28, 1899.)—A description of the electrical equipment of this line, which was formerly worked by steam. Three Ball and Wood compound tandem engines with fly-wheels 78 in. × 17 in. face running at 235 r.p.m. are coupled direct to B.T.H. generators, which, with the rest of the installation, are on the usual lines. E. H. C.-H.

1592. *Washington Tramways.* (Street Rly. Rev. 9. pp. 365–373, June 15, 1899.)—All the lines in Washington except those of the Capital Traction Company are being consolidated into the Washington Traction and Electric Company. Through service from the suburbs to any part of the city for a single fare is one of the features. Overhead construction is used in the suburbs; underground conduit in the city. The chief line absorbed is the Metropolitan Railroad Company, which operates 307 cars. Its repair shops are well equipped with machine tools, which are operated by a 20 H.P. motor. The machinery under the cars is cleaned by compressed air-jets at 60 lb. pressure. Every car is overhauled twice a month. The generating station is of the usual McIntosh and Seymour and General Electric pattern. Alongside the feeder panels is an emergency panel, having a water rheostat in series with it. When a short circuit occurs on any feeder it is switched on to this panel and the water resistance varied so as to burn out the short circuit if possible. The fans for the Worthington cooling tower are driven by a special direct-coupled G.E. motor, which has a possible speed variation of 100 per cent. The boilers are connected to a self-supporting steel stack, 6 feet in diameter and 125 feet high.

The conductor rails for the underground system are T-rails, 22 feet long, fastened at their ends and centre to insulators. The plough is 2 feet long by 8 inches wide, built up of steel bars. Two sets of leads from it are provided, one with fuses, one without, the latter being put in circuit when the fuses on the former blow.

The feeders are connected to the rails with special sweated clamps: trouble previously arose through omission of solder.

The Columbia Company, operating 52 cars, has a similar system, with the addition of a plough carriage which is automatically attached to the truck at the end of the overhead system. Some of the other lines receive two-phase current at 6,500 volts from the Potomac Power Company, and transform down in sub-stations to 500 volts direct. E. H. C.-H.

1593. *Accumulator Traction in Bremerhaven.* **Sieg.** (Elektrotechn. Ztschr. 20. pp. 324–344, 1899.)—The line is 4·3 km. long and is worked with accumulators, overhead wires being forbidden in Bremerhaven. Four motor cars and two trailers are in use. The former hold twenty passengers standing and twenty sitting, and weigh seven tons when empty. They carry two 10 H.P. motors with 1 : 4 spur gearing, and batteries of eighty-six cells with four positive and five negative plates, each 20 cm. broad, 30 cm. high, by about 5 mm. thick. The plates are separated by perforated rubber sheets, and the cells are hermetically sealed, provision being made for the escape of gas through a common tube. The whole battery complete weighs 2·5 tons and the car loaded complete twelve tons. One charge suffices for 60 km. The charge put into each car is measured in watt-hours. The conditions are favourable for accumulator working in so far as concerns the absence of hills, but unfavourable on account of the dirty state of the streets and frequent stoppages at the thirty-nine level crossings. Without trailers the energy required was 470 watt-hours of charge per car-km. No actual figures of the cost of maintenance of the batteries can yet be given, but the Cologne Accumulator Company are prepared to maintain the cells for 2·5 pfennigs per car-km. By actual tests of a car on a length of 1 km. the author obtained the following figures on different notches of the controller, the car carrying only three people:—

Notch No.	Energy used per km.	Speed.
3	200 watt-hrs.	10 km. per hr.
4	240 „	15·7 „
5	260 „	17·75 „
6	260 „	18·3 „
7	360 „	26 „

And with one empty trailer added—

Notch No.	Energy used per km.	Speed.
5	311 watt-hrs.	16 km. per hr.
6	340 „	17 „

E. H. C.-H.

1594. *Comparison of Electric and Steam Traction.* **B. H. Thwaite.** (Eng. Mag. 17. pp. 415–425, June, 1899.)—A steam locomotive has to employ half its own tractive force in moving itself on the level. The total costs per ton mile, including supervision, motive and train wages, coal, oil, water, cleaning and repairs of rolling stock, are 0·1245d. on the Liverpool Electric Overhead Railway, 0·190d. on the Manhattan (steam) Railway, 0·152 on the Brooklyn Elevated, and 0·171 for the average American steam locomotive practice. On a train mile basis the relative coal consumption on comparable electric and steam railways is as 16 to 41. The fuel for power at the axle of the electric train does not exceed 2·6 lb. of coal per H.P. hour of tractive effort; in the best steam locomotives this figure would be 3·3 lb.

E. H. C.-H.

1595. *Electric Locomotive of the Paris-Lyons Mediterranée Company*. (Elect. World, 33. pp. 146–147, 1899.)—This company has been experimenting with an electric locomotive for some eight months with a view to electrical operation of the main line from Paris to Melun, with branches totalling sixty-five miles. The body of the locomotive is V-shaped in front. The running gear is on standard French lines, with one idle leading axle and two driving axles. All six wheels are 44 inches diameter; wheel base overall, 20 feet; between drivers, 7 feet. The axle-boxes of the leading wheels are inside and support the load through inclined planes which give the wheels about ½ inch play to either side. The armatures are 27 inches diameter by 22 inches active length, and carry 150 copper bars of $\frac{1}{10}$ square inch sectional area insulated in micanite tubes. They have commutators at each end, each provided with two sets of carbon brushes. The armatures are mounted directly on the wheel axles. A 4 kw. air-compressor operates the brakes, whistle, and controlling devices. A battery of eighteen cells serves for separate field excitation. The main current is controlled by a special water rheostat consisting of an iron box of 60 cubic feet capacity, into which hang twenty lead plates. The bottom of this box is connected with a large reservoir containing carbonate of soda solution and connected with the compressed-air system. The circuit is thus closed through a decreasing resistance by the rise of the solution up the lead plate. When the box is full an auxiliary circuit is closed which operates a short-circuiting switch, cutting out the rheostat. To stop the motors it is only necessary to release the air-pressure on the lower reservoir. This operation is automatically performed by a circuit breaker when the current reaches 1,200 amperes. The fields are separately excited by the auxiliary battery through four mercury switches, by means of which the magnetisation can be reversed to secure reverse motion of the locomotive. All the switches are suitably interlocked. The main battery consists of 192 Fulmen cells carried in a separate tender. Each plate is enclosed in a perforated celluloid envelope, those surrounding the positive plates being internally lined with asbestos cloth.

The positive and negative plates in their envelopes are separated by square rods of celluloid. Each cell has twenty-nine plates, weighing together 175 lb. The capacity of the battery is 500 amperes for 1¾ hours.

The results obtained are: Maximum load drawn (including tender but not locomotive itself) 147 metric tons, which were propelled at 30 m.p.h. with the motors in series. A higher speed was impossible without exceeding the safe current from the battery. With the motors in parallel a speed of one mile per minute has been obtained with a load of 100 metric tons. The armatures can carry continuously 700 amperes, which at a speed of 500 r.p.m., equivalent to 60 m.p.h., would require an E.M.F. of 360 volts, the two armatures under these conditions absorbing roughly 500 kw. Estimating their efficiency at 90 per cent. the effective output would be about 611 H.P. By doubling the number of driving motors and wheels the full power of standard steam locomotives could be obtained. E. H. C.-H.

1596. *Train Resistance.* **H. Graftio.** (Street Rly. Journ. 15. pp. 293–297, 1899.)—Many interesting tests on the resistance of trains and of locomotives have been made during the last few years. From experiments made in the United States, A. Sinclair showed that the relation $R=a+bv$ held between the speed limits 60 and 120 km. per hour. Desdouit found that the resistance of locomotive and tender increased very nearly as a function of the speed, of the form $R=a+\sqrt{b+cv^2}$. The author has plotted curves from the data of Desdouit, Privat, engineer of the Paris-Lyons-Mediterranean Railway, Barbier on the French Northern Railway, and Petroff. He expresses the maximum and minimum resistances of a locomotive by the formula—

$$R_{\text{min.}} = 5{\cdot}24 + 0{\cdot}14v - \frac{129}{v},$$

$$R_{\text{max.}} = 14{\cdot}38 + 0{\cdot}12v - \frac{432}{v},$$

which hold between the limits 60 and 95 km. per hour. All the latest experiments seem to prove that the resistance of the locomotive increases very nearly as the speed.

The resistance of the cars only of a train is represented by a curve of a well-marked parabolic form, while the resistance curve of a locomotive is generally of hyperbolic form. Petroff's formula for resistance of cars only is—

$$R = 1{\cdot}2 + \frac{0{\cdot}6n}{Q}v + \frac{0{\cdot}03}{Q}(1 + 0{\cdot}004n)v^2,$$

where R is the resistance in kilograms per ton of the cars, Q is the weight of the cars, *n* the number of cars, and *v* the speed in kilometres per hour. The formula was found by careful study of all the causes of resistance, and having established the general form of the equation, Petroff found the most probable values of coefficients from a very large number of experimental data.

The author combines the resistance of the locomotive and the cars and gives curves for the resistance of complete trains. The paper is illustrated by five groups of curves. A. S.

1597. *Electric Motor Cars.* **F. Wilking.** (Elektrotechn. Ztschr. 20. pp. 364–369, 1899.)—A description of the electric 'buses, wagonettes, &c., and trade carts of the Gesellschaft für Verkehrsunternehmungen. The 'bus, holding twelve seated and six standing, weighs complete 3,500 kg. After a journey of 8 km. the cells are charged up in fifteen minutes. E. H. C.-H.

1598. *Electric Motor Cars.* **E. Egger.** (Zeitschr. Elektrotechn. Wien, 17. pp. 58–60, 78–81, and 91–96, 1899.)—The requirements of an automobile in the order of their importance are (1) independence of the driving wheels from one another; (2) smallest possible resistance to motion; (3) easy steering; (4) capability of surmounting all hills; (5) rational weight; (6) sufficient speed and easy regulation of same; (7) economical working. The author then proceeds to discuss the methods adopted for obtaining these requirements, chiefly referring to carriages shown in the Paris automobile show, 1898. The first requirement can be satisfied either by use of differential gear between the wheels or by having an independent motor to each wheel. On an average the relative resistance to motion of pneumatic and iron tires is 100 to 152. Particulars are given of the cells of certain vehicles and estimates of the relative working expenses of electric and horse-drawn carriages. Chauveaux gives the following relation between the power, M, of the motor in horse-power: p, the number of persons carried; v, the speed in kilometres per hour; viz., M/pv=a constant. On this basis the winner of the Marseilles-Nice-La Turbie race, whose constant worked out at 0·11, should only have taken fifth prize, while an outsider, whose constant worked out at 0·034, should have taken first honours. E. H. C.-H.

1599. *A "Torpedo" Motor Car.* (Automotor Journal, 3. p. 347, 1899.)—A car known as "La Jamais Contente" has been built for M. Jenatzy with a body resembling a submarine torpedo-boat. The driver sits in a hole in the rear. The motors, worked from Fulmen accumulators, are direct coupled to the driving (rear) wheels, which are therefore made small in diameter. The car has covered one mile in 61·8 seconds. E. H. C.-H.

1600. *Paris Electric Cabs.* (Automotor Journal, 3. pp. 457–459, June, 1899.)—As a result of the exhaustive cab trials by the French Automobile Club the Compagnie Génerale des Petites Voitures, who own 8,500 vehicles and 12,300 horses, decided to gradually abandon horse-traction and adopt electric. The Bersey system, as employed on the London electric cabs, was adopted on account of its simplicity and in spite of the bad appearance of its battery tray. The steering is by means of a pinion working in a wheel on the front axle framing, the pinion-shaft being rotated by the hand-wheel through a worm. This steering gear is sufficiently quick and is irreversible: the front wheels cannot rotate the hand-wheel. Forty-three cells are carried, said to weigh 1,760 lb., but no data are available as to capacity. The makers have a maintenance contract. The motor is by Postel-Vinay, drum-wound with two separate circuits and two sets of magnets. This gives better graduation in speed and provides a standby. The motor weighs 211 lb. and is rated at 3 kw. at 1,500 r.p.m. To one end of the armature shaft is keyed a compressed leather pinion, gearing into the crown-wheel of the differential gear, which is mounted on an intermediate shaft. Upon each end of the latter is keyed a pinion, gearing with the wheels through a "Sebin" chain, which has been adopted in place of the Renolds chains used in London.

The Company have extensive trial grounds with graded roads, dummy obstacles, &c. E. H. C.-H

1601. *Moving Platform Railway of the Paris Exhibition.* **E. Miot.** (Électricien, 17. pp. 177–180, 1899.)—This is a descriptive account of the moving platform railway which is being constructed for the Paris Exhibition of 1900. (See 1898, Abstract No. 338.) W. G. R.

1602. *Precursors of Nernst's Lamp.* **E. de Fodor.** (Zeitschr. Elektrotechn. Wien, 17. pp. 172–178, 1899. Report to the Elektrotechnischer Verein in Wien, March 20, 1899.)—A historical sketch of the gradual evolution of the various forms of incandescent electric lamps. The author points out that Nernst has been anticipated by Jablochkoff, who in 1877 patented a lamp in which a strip of half-baked kaolin (1½ in. long, 1 cm. wide, and 2 mm. thick) was used as the light-giving portion; and by Edison, who, besides constructing lamps having all sorts of refractory substances for their incandescent portion, actually used a fine platinum spiral for the initial heating of the lamp. A. H.

1603. *Three-Arc 110-Volt Lighting System.* **J. Zeidler.** (Elektrotechn. Ztschr. 20. pp. 241–243, 1899.)—By using special

carbons, between which an arc of sufficient length may be maintained at a P.D. of 35 volts, and an automatic steadying resistance controlled by a coil-and-plunger mechanism, the Allgemeine Elektricitäts-Gesellschaft of Berlin has recently succeeded in running three arc lamps in series off 110-volt mains. The lamp mechanism must be capable of responding rapidly to changes of current, and it is further necessary that the P.D. across the mains should be kept very constant. The lamps used are of the clock type, with hinged clockwork frame controlled by the differential action between a series and a shunt electromagnet.
A. H.

1604. *Arc Lamps.* **E. W. Lehmann-Richter.** (Elekt. Runds. 16. pp. 42–43, 1898.)—A statement of the results of observations on constant current arc lamps, the variations in length of arc, current strength, and potential difference are given, showing the manner of working the lamp and the importance of a system of regulation.
J. J. S.

1605. *Test of an Enclosed Arc Lamp.* **E. Gerard** and **O. de Bast.** (Bull. Ass. Ing. El. Liège, 10. pp. 197–198, 1898–1899.)—The lamp tested was constructed to take 4·5 amperes at 108 volts. The arc was enclosed in a transparent cylindrical globe

Two tests were made: the first with new carbons and clean globe; the second after the lamp had been run for about 103 hours.

The following table gives the results obtained:—

	Test No. 1.	Test No. 2.	
Mean voltage between lamp terminals	108·1	107·4	volts.
Mean current	4·53	4·46	amperes.
Mean power absorbed	489·7	479	watts.
Mean spherical intensity	168·8	129·5	candles (decimal).
Mean hemispherical intensity (lower hemisphere)	199·8	157·5	candles (decimal).
Number of watts consumed per mean spherical candle	2·9	3·71	
Number of watts consumed per mean hemispherical candle	2·45	3·047	

In the calculations one carcel is taken to equal 9·62 candles.

The life of a single pair of carbons is 110 hours and 20 minutes.
W. G. R.

TELEGRAPHY AND TELEPHONY.

1606. *Wireless Telegraphy in the French Navy.* **Tissot.** (Paris Soc. Franc. Phys. Bull. 130. p. 2, 1899.)—Tissot employs platinum electrodes in his coherers. The filings are silver, somewhat covered with sulphide. The current density is kept high, and the tubes are therefore semi-capillary. The receiving wires are not connected to any capacious body, and it is not necessary that they should be vertical, but they should be at right angles to the direction of propagation. M. O'G.

1607. *Telediagraph.* (Elect. World and Engineer. 33. p. 581, 1899.)—This article describes the Hummell apparatus for transmitting pictures by an electrical process. The picture to be transmitted is drawn with insulating ink on heavy metal foil. The foil is then bent once round the horizontal cylinder of the transmitter and is there clamped. There is a similar cylinder on the receiver, and on this are wrapped two sheets of paper with a carbon sheet between them. The transmitting cylinder rotates under a stylus which, when it touches the foil, closes the circuit between the transmitter and receiver. The current through the receiver causes a corresponding stylus to descend upon the paper. A synchronising arrangement keeps the cylinders progressing at equal rates along and round equal screw-threads. The arrangement is an improved form of the Caselli telediagraph. R. A.

1608. *Telephone Engineering.* **T. Spencer.** (Proc. Eng. Club. Phil. 16. pp. 129–144, 1899.)—The author separates the talking system from the signal system in any exchange, and claims supremacy for centralised power stations. A telephone responds to 6×10^{-13} amperes, and by induction between two circuits having one inch of parallel line $\frac{1}{16}$ in. apart (and using standard apparatus) overhearing is complete. The static induction is twenty times the magnetic. Hence the sides of each circuit must have the same insulation and conductivity, and must be raised to the same potential by displacement currents from a disturbing source. Superposed load-diagrams of London and New York telephone exchanges suggest that the use of an Atlantic talking cable might be too small to pay, owing to business hours closing at one place when they open at the other. Curves are given showing the proportion of good calls to busy calls. The importance is pointed out of a subscriber having two telephone lines, so that his own outgoing work may not choke off incoming communications. M. O'G.

1609. *Induction in Telephone Circuits.* **Colard.** (Bull. Ass. Ing. El. Liège, 10. pp. 95–133, 1898–1899.)—The distribution of current and potential in two parallel single wire telephone circuits is mathematically studied, taking account of their resistance, mutual capacity, self-induction, mutual induction, and mutual insulation, uniformly distributed, as well as the resistance and self-induction of the apparatus at the extremities of the circuits. In what follows, i_1 i_2 are the currents in the two wires, and E_1 and E_2 their potentials. The expressions given below for i_1+i_2, E_1+E_2, and i_1-i_2, E_1-E_2, are obtained by a lengthy mathematical investigation.

$$i_1+i_2=\frac{E}{2(R^2+S^2p^2)}\Big[R\sin pt-Sp\cos pt\Big]$$

$$E_1+E_2=\frac{E}{2}\left(1-\frac{x}{l}\right)\sin pt+\frac{E}{2(R^2+S^2p^2)}\frac{x}{l}\Big[(rR-sSp^2)\sin pt-(rS-sR\cos pt\Big]$$

$$E_1-E_2=\frac{E}{2}\Big\{-AShax\sin\left[pt+\beta(x+l)-\phi\right]+BChax\sin\left[pt+\beta(x+l)-\gamma\right]\Big\}$$

$$i_1-i_2=\frac{EU}{2}\begin{Bmatrix}AChax\cos\left[pt+\beta(x+l)-\phi-\theta\right]\\-BShax\cos\left[pt+\beta(x+l)-\gamma-\theta\right]\end{Bmatrix}$$

The way to use these formulæ arithmetically is indicated in detail, and a useful example worked. Two lines 15 metres high, 30 centimetres apart, having 34·6 ohms per kilometre. From Uppenborn Kalender fur Elektrotechniker, 1898, page 68, the coefficient of self-induction for unit length of wire with earth return is taken as

$$\rho=2\log_e\frac{2h\ \text{(metres)}}{r\ \text{(wire radius)}}$$

Uppenborn's formula (page 60) for capacity per kilometre in mfds. is

$$\frac{0{\cdot}01206}{\log_{10}\frac{d}{r}}=0{\cdot}0000458\ \text{farads per quadrant in the above example.}$$

The mutual induction coefficient is

$$\mu=2\log_e\frac{2h}{d}=9{\cdot}22\ \text{henrys per quadrant.}$$

From these the current received at either end of the line, both induced and received direct [for various frequencies from 1,000 to 100], is tabulated. The received currents in both lines per volt applied for various lengths of the wires is separately tabulated, and it is pointed out that it is not correct in practice or in theory to simply superpose the effect of electrostatic induction calculated by itself on to electromagnetic induction in order to obtain the total. The simultaneous existence of the two inductions must be allowed for. The author finds that for lines of moderate length, with moderate frequencies, an exceptionally low insulation between the wires has not the effect of increasing the induction, and leakages due to this cause have only a very secondary effect upon the induced currents. M. O'G.

1610. *Air-tight Cable Conduits.* (Electrician, 43. pp. 124–125, 1899.)—Morten and Kenney propose to use a 6 feet cast iron conduit permanently kept under dry-air pressure, using paper 1,000-wire cables inside it without lead covering; the economy on lead-covered cables drawn into pipes being stated at £11,000 per mile with ten cables. M. O'G.

1611. *Minor Telephone Troubles.* **H. P. Clausen.** (West. Electn. 24. pp. 353–354, June 24, 1899.)—Hand telephones suffer from variations of temperature changing the distance between the magnet and the diaphragm, from the permanent magnet losing its magnetism through accidental heavy currents direct or alternating, and from burned-out or crossed wires. The diaphragms of microphones are liable to break if made of carbon; packing is easily cured by putting in new granules. Hints on rewinding the secondary of the induction coils are given. Magnetos wear at the bearings, at the armature contact-pin, and in the windings. Simple remedies for the above are given. M. O'G.

1612. *Edison's Motograph as a Telephone Repeater.* (West. Electn. 24. p. 361, 1899.)—A rotating cylinder of plaster of Paris moistened with a certain solution is in contact with a strip of platinum, which adheres to it or not according as a current is passing; this increase or decrease of tension is transmitted to a diaphragm which it is proposed to utilise as a transmitter for repetitions. M. O'G.

1613. *Edison's Motograph as a Telephone Relay.* **W. J. Hammer.** (Elect. World and Engineer. 33. pp. 752–754, June 3, 1899.)—Gives details and diagrams of his work on this in 1899. M. O'G.

1614. *Long-Distance Telephony.* **J. H. Winfield.** (West. Electn. 24. pp. 361–362, June 24, 1899. Paper read before the Maritime Electrical Association at Halifax, April 18, 1899.)—Clearness is more important than timbre and volume and is affected by conditions which alter the position of the waves in regard to each other. It is reduced by static- and self-induction, as these tend to unequally retard vibrations of different periods. Static-induction rounds the top of the waves, losing sharpness. The avoidance of iron wires, the use of leakage, and the crossing of wires are discussed, and various apparatus described.

M. O'G.

1615. *Automatic Call Register.* **H. T. Richards.** (Elect. Rev. N.Y. 34. p. 333, 1899.)—H. T. Richards (of 225, West Twenty-eighth Street, New York) has devised a register, which he places on the subscriber's instrument and at the exchange. Both are moved one number ahead by the operator previous to making connection by projecting a current through them.

M. O'G.

1616. *Telephone Exchange System.* **G. Ritter.** (Elektrotechn. Ztschr. 20. pp. 249–253, 265–268, and 283–286, 1899.)—Details are given of the telephone arrangements at Württemberg. R. A.